U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 237.

A. C. TRUE, Director.

IRRIGATION IN CALIFORNIA.

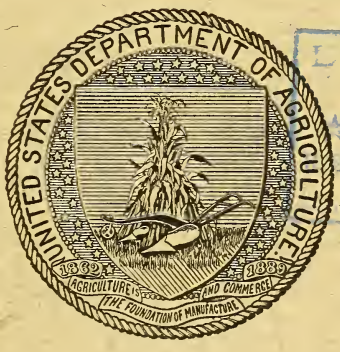
BY

F. W. ROEDING,
Irrigation Manager.

PREPARED UNDER THE DIRECTION OF

SAMUEL FORTIER,
Chief of Irrigation Investigation.

[The work on which this report is based was done under a cooperative agreement between the Office of Experiment Stations of the U. S. Department of Agriculture and the State of California.]



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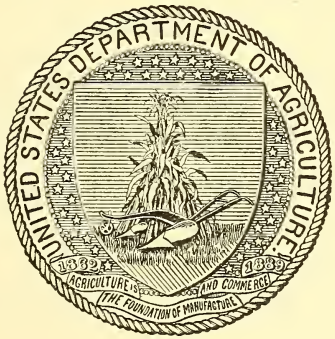

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OFFICE OF EXPERIMENT STATIONS.

A. C. True, Director.
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Samuel Fortier, Chief.
R. P. Teele, Assistant Chief.

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 27, 1911.

Sir: I have the honor to transmit herewith a report on irrigation in California, prepared by F. W. Roeding, irrigation manager, under the direction of Samuel Fortier, chief of irrigation investigations of this Office. This is one of a series of reports dealing with irrigation in the arid States and Territories prepared for the purpose of answering inquiries regarding conditions and the opportunities and cost of settlement which come to this Department in great numbers. The work on this report was done under a cooperative agreement between the Office of Experiment Stations and the State of California, each paying half the expenses.

It is recommended that the report be published as a bulletin of this Office.

Respectfully,

A. C. True,
Director.

Hon. Jas. Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATE.

FIGURES.

IRRIGATION IN CALIFORNIA.

GENERAL DESCRIPTION.

The State of California extends from the Mexican Territory of Lower California to Oregon and has a coast line bordering the Pacific Ocean of about 800 miles and an average breadth of 200 miles. It is the second State in the Union in size, having an area of 158,297 square miles. Nearly seven-eighths of its surface is covered by mountains, which divide into two main ranges, known as the Sierra Nevada on the east and the Coast Range along the ocean. These ranges unite in both the northern and the south central parts of the State and continue beyond the State in both directions as practically one range. The Sierras are a high, rugged, and continuous range, 6,000 to 14,500 feet high, and heavily timbered on the western slopes. In the south central and northern portions of the State they tend westward from the eastern border of the State, leaving valleys and isolated ranges which are practically arid. In the southeastern part of the State the lands are below sea level, and it is remarkable that Mount Whitney, the highest peak in the United States, having an elevation of 14,502 feet, and Death Valley, the lowest point on the continent, being 427 feet below sea level, are within 70 miles of each other.

The Coast Range is lower and is made up of numerous chains, interspersed with valleys, some of the elevations being high and rough, others low, rolling hill lands. Its continuity is broken only in one place—where San Francisco Bay and its arms are joined to the ocean by the famous Golden Gate. Its crest varies in elevation from a few hundred feet to 7,000 feet. The northern half of this range contains magnificent forests, principally redwood, but toward the southern boundary the ridges become more or less bare and sharp.

In the north central portion of the State between these two ranges lie the great interior plains. There are many smaller valleys of considerable area and great fertility throughout the State, particularly those along the coast.

CLIMATE.

Possibly nothing has attracted so much attention to the State as its unusual climatic conditions and their general uniformity. The months of June, July, August, and September are rainless, practically without exception, while the rainy season extends from October to May, inclusive. The heaviest precipitation occurs between November and March, and the annual amount increases with the latitude and altitude.

California may be divided meteorologically, in a very general way, into three sections paralleling the coast. The first extends inland 5 to 20 miles from the shore of the Pacific and its arms. In this section the temperature is almost uniform throughout the year, extremes of heat and cold being unusual. The second division extends from the east line of the first to the summit of the Sierras and their extensions. The winters are mild here also, but the summer temperatures are high, although not unbearable owing to the very low humidity. The rainfall throughout this section is relatively less than that of the coast region, except in the higher elevations. The third section extends from the summit of the Sierras to the eastern border of the State. The rainfall is very light throughout this section and there is a greater range between the summer and the winter temperatures than in the other sections. Imperial and Death Valleys, both of which are below sea level, show the highest summer temperatures in this division. The winters there, although they show higher monthly means and higher maxima than corresponding points in the other two divisions, have lower minima. The valleys in the extreme northern part of this division range from 4,000 to 8,000 feet in elevation and much lower temperatures are experienced than on the western slopes of the Sierras at the same elevation.

The following table, compiled from reports of the United States Weather Bureau,[1] shows the elevation; the absolute highest, absolute lowest, and the mean annual temperatures; and the greatest and smallest seasonal and the normal annual rainfall at points about equidistant from north to south in each of the above divisions:

Variations in temperature and precipitation in different sections of California.

Sections and stations.	Length of record.	Elevation.	Temperature.			Rainfall.		
			Absolute highest.	Absolute lowest.	Mean annual.	Greatest seasonal.[2]	Smallest seasonal.	Normal annual.
Coast section:	*Years.*	*Feet.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
San Diego	39	93	101	32	60.8	5.96	3.66	10.5
San Francisco	39	207	101	29	55.0	46.42	9.96	24.2
Eureka	24	64	85	20	51.4	78.92	25.52	45.9
Central section:								
Redlands[3]	17	1,352	113	25	63.6	25.78	6.30	14.7
Merced[4]	36	173	120	16	63.2	23.7	4.2	10.3
Red Bluff	33	307	114	18	62.5	41.87	46.9	26.1
Eastern section:								
Salton[5]	17	−263	128	18	76.9	9.39	T.	2.6
Independence	14	3,907	105	3	58.6	8.08	1.9	5.6
Cedarville	16	4,675	107	−13	47.7	22.18	9.3	13.9

[1] Bulletins L and Q and annual summaries of the California section of the Climate and Crop Section for the years 1904–1909, inclusive.
[2] July 1 to June 30.
[3] Records for 1904 missing.
[4] Precipitation at Merced less than that of Redlands, as latter is west of Coast Range; otherwise precipitation increases uniformly from south to north. Same is true in central region if the normal annual rainfall of Bakersfield, Merced, Sacramento, and Red Bluff be taken. These are respectively 4.81, 10.3, 20.87, and 26.1 inches.
[5] Last record 1905.

The mean monthly and annual temperatures and the mean monthly and annual precipitation at stations in different parts of the State are given in the following tables compiled from the annual summary of the United States Weather Bureau for California for the year 1909:

Mean monthly and annual temperatures at stations in California.

Stations.	Length of record.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	Years.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
San Diego...	39	54.0	54.6	56.2	58.2	60.8	63.8	66.9	68.7	66.9	63.0	59.0	55.7	60.8
San Francisco.....	39	49.5	51.3	52.7	53.7	55.5	57.0	57.3	58.0	59.3	58.4	55.5	50.9	55.0
Eureka.....	24	46.9	46.8	48.0	49.5	52.1	54.6	55.3	55.8	54.9	53.1	51.0	48.0	51.4
Redlands...	17	50.8	52.2	54.7	61.1	65.8	73.8	78.3	77.5	72.1	65.0	58.9	53.2	63.6
Merced.....	36	47.0	51.0	55.0	60.0	67.3	75.3	81.7	79.3	73.7	64.8	55.4	48.3	63.2
Red Bluff...	33	45.4	49.3	53.8	59.1	66.5	75.7	82.1	80.0	73.9	63.8	53.4	46.4	62.5
Salton[1].....	17	55.7	58.8	66.0	76.6	83.1	93.8	98.9	97.2	91.0	79.1	66.8	56.1	76.9
Independence.....	14	40.5	43.7	49.6	56.7	64.5	73.4	78.5	76.4	69.1	59.3	49.2	41.6	58.6
Cedarville...	16	31.5	34.9	37.3	42.3	51.9	60.5	69.2	67.9	78.6	48.9	38.9	30.2	47.7

[1] Annual summary, 1905.

Normal monthly and annual precipitation at stations in California.

Stations.	Length of record.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	Years.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
San Diego...	39	2.02	2.26	1.54	0.76	0.37	0.06	0.01	0.12	0.06	0.40	0.78	2.13	10.51
San Francisco.....	39	4.75	3.69	3.08	1.97	.75	.24	.02	.01	.27	1.70	2.68	5.03	24.19
Eureka.....	24	7.59	6.72	6.18	4.28	2.83	1.18	.09	.14	1.38	2.90	5.32	7.28	45.89
Redlands...	17	2.59	2.67	2.63	.55	.76	.10	.04	.52	.37	.68	.94	2.86	14.71
Merced.....	38	2.10	1.31	1.44	1.06	.57	.16	.01	.02	.18	.51	1.25	1.70	10.31
Red Bluff...	33	4.67	3.70	3.27	2.16	1.33	.49	.03	.02	.67	1.36	3.10	5.31	26.11
Salton[1].....	17	.43	.62	.21	.00	.07	.00	.19	.14	.13	.12	.12	.55	2.58
Independence.....	14	1.22	.57	.48	.20	.29	.04	.11	.22	.07	.32	.11	2.00	5.63
Cedarville...	16	1.41	1.33	1.48	1.00	1.60	.59	.30	.26	.42	1.60	2.08	1.87	13.94

[1] Annual summary, 1905.

Thunder showers are rare except in the high elevations of the Sierras, where they occur occasionally throughout the summer.

Winds of high velocity are very unusual, and such strong winds as do occur are confined as a rule to the spring months, except close to the coast, where trade winds from the ocean blow throughout the spring and summer months.

Killing frosts in the lower altitudes are confined almost entirely to the winter months of December, January, and February. Occasional heavy frosts have occurred in the great agricultural sections in October and April, but an entire failure of crops from this cause is unknown.

Altogether the topography has a marked influence on the climate, the mild climate being due chiefly to the ocean currents which carry the warm waters from the Tropics far up the coast.

POPULATION.

The population of the State according to the census of 1910 was 2,377,549. There were 31 cities in the State with a population over 5,000 each, divided as follows:

Population of 31 cities of California.

San Francisco	416,912
Los Angeles	319,198
Oakland	150,174
Two cities with	40,000–50,000
Six cities with	20,000–40,000
Ten cities with	10,000–20,000
Ten cities with	5,000–10,000

The greatest concentration is within a radius of 50 miles of the two principal cities—San Francisco and Los Angeles. That this present density is slight as compared with the area of the State is self-evident, and it is not unusual in years of a heavy yield of agricultural products that considerable trouble is experienced in securing the necessary labor. The constant and rapid increase in population and the breaking up of large areas into small farms intensively cultivated will gradually eliminate these conditions.

INDUSTRIES.

Agriculture is the dominant industry, manufacturing, which is dependent largely on products of the farm and with which it is therefore related closely, being second. The other prominent industries are lumbering and mining, in the order named.

For the year 1907, according to the latest report of the State board of trade, the value of products was as follows:

Value of different products.

Agricultural:	
Crops of all kinds	$181,072,060
Farm animals and their products	70,447,286
Forest products: Cut lumber, tan bark, poles, ties, etc.	97,344,850
Mineral: Gold, copper, petroleum, cement, etc.	50,588,565

The manufactured products are placed at a total of approximately $350,000,000, but as they are included, to a considerable extent, in the three foregoing divisions, they can not well be segretated. Among prominent industries which are not so related are shipbuilding and the manufacture of explosives, machinery, and steel and iron products.

ASSESSED VALUATION.

The report of the State board of equalization for 1908 shows a total value of all property subject to State taxation of $1,991,554,603, divided as follows:

Assessed valuation of property in 1908.

Real estate and improvements	$1,546,353,790
Personal property, money, and solvent credits	328,502,651
Railroads	116,698,162
Total	1,991,554,603

The State tax rate was 0.4 per cent.

Real estate, other than city or town lots, subject to assessment covered an area of 43,029,922 acres and had a value of $439,461,278, to which $94,740,154 should be added for improvements, making a total of $534,201,432, or a unit value of $12.42 per acre on approximately 43 per cent of the land surface of the State. About two-fifths of this area is agricultural land and the balance timber, grazing and mining property under private ownership. State school lands and other lands exempt from taxation are not included in the above area.

TRANSPORTATION FACILITIES.

The mileage within the State of intercounty roads, both steam and electric, which is subject to State assessment, is nearly 6,000. There are also a number of roads which do both passenger and freight business entirely within one county. Two transcontinental lines, the Southern Pacific and Santa Fe systems, cover the greater portion of the developed sections, and are to be increased soon by the Western Pacific. The San Pedro, Los Angeles & Salt Lake Railroad taps a considerable portion of southern California. A number of electric roads are in operation also through agricultural sections, the Northern Electric, which operates in the Sacramento Valley between Sacramento, Chico, Hamilton City, and Oroville, being the longest—117 miles. The development of hydro-electric plants on the numerous Sierra streams has reached considerable proportions and is being augmented continually, so that cheap power is furnished for the operation of electric roads. Under such conditions it is safe to say that the State will soon have a network of such transportation facilities as will aid greatly in the development of the isolated sections.

Navigation enters also into the economical carrying of passengers and freight. San Francisco Bay, with its northern arms, San Pablo and Suisun Bays, covers an area of about 400 square miles, excluding

tide lands along its borders. It is one of the few harbors along the coast and has few equals as a harbor. The two navigable rivers of the State—the Sacramento and the San Joaquin—empty into it by way of Suisun Bay and form arteries of trade by boat with the great central plains. Other harbors of importance are San Diego, San Pedro, Santa Monica, Monterey, and Humboldt Bays, the first and last of which are landlocked. San Pedro is protected artificially by an immense breakwater constructed by the Government, and Monterey and Santa Monica Bays are open roadsteads. Besides the coastwise and internal traffic possibilities, steamer lines and sailing vessels connect the principal harbors of the State with all ports of the world.

WATER RESOURCES.

The Sierra Nevada Mountains mark the division line between the semiarid and the arid sections of the State. The crests of the range rise to such an altitude that they interrupt the rain-laden clouds from the Pacific and cause their moisture to be precipitated on the western slopes. It has been shown also that the yearly amount of rainfall increases to the north, and it is evident therefore that no stream of any size would be found in the southern portion of the State. This is true especially on account of the limiting of the size of the drainage basins due to the westward trend of the summit of the ranges after joining at Tehachapi. (Pl. I.)

No State in the Union makes such extensive use of its water resources as California. Aside from the large areas irrigated, hydroelectric plants, principally on the numerous streams of the Sierras, produce 500,000 horsepower[1] for lighting its cities, operating electric roads, and serving manufacturing plants. Water power is used also in a considerable measure throughout the mining regions.

What is usually termed the San Francisco Bay drainage is the most important water division. Irrigation is largely a necessity in growing crops other than cereals on its great central plains, which contain about one-half of the arable lands of California. Besides the Sacramento and San Joaquin Rivers[2] the water division includes a number of smaller creeks which pour their supplies directly into the bay. The area of this immense drainage basin is estimated roughly as 62,000 square miles, divided as follows: Sacramento River, 27,500; San Joaquin, 31,500; San Francisco Bay streams, 3,000 square miles. The approximate division between the San Joaquin and Sacramento drainage valleys is a line drawn northeast from their junction, at the head of Suisun Bay. The former has a length

[1] Blanchfield's Western Electric and Gas Directory, August, 1908.

[2] San Joaquin River includes Kings, Tule, Kaweah, and Kern Rivers, and smaller streams throughout what was once known as the Tulare Valley, although none enters the San Joaquin direct, but in times of flood their only exit to the ocean is by means of that stream, so they are included in the basin.

MAP OF CALIFORNIA SHOWING STREAMS AVAILABLE FOR IRRIGATION.

of 225 miles from Stockton to Sunset City and an average width of 45 miles, and contains about two and one-third times as much valley land as the latter, which is only about 190 miles long from Stockton to Redding and averages only 25 miles in width. The water resources of the northern drainage basin, although smaller in extent, are much greater than those of the southern, owing to the heavier rainfall. There are three important tributaries heading on the eastern slopes of the coast range, while there is none of any consequence from these mountains in the San Joaquin Valley. The principal streams from the Sierras which make up the two main arteries of these valleys are of considerable size and flow throughout.

SACRAMENTO RIVER DRAINAGE.

The chief streams of the Sacramento Valley are the Sacramento, the Pitt, the McCloud, the Feather and its tributaries, the Yuba and Bear Rivers, and the American River, flowing from the Sierras, and Stoney, Cache, and Putah Creeks from the Coast Range.

The Sacramento River rises on the southwestern slope of Mount Shasta, and flows south until it emerges from its rocky canyons and enters the valleys near Redding, where it continues its course south through the trough of this valley, and discharges its waters into Suisun Bay at a point almost due west of Stockton. The volume of the river is relieved during high water by numerous basins in the swamp land which line its lower reaches.

The Pitt River is the first important tributary. It has its source in the extreme northeast corner of the State and takes the overflow of Goose Lake and the run-off of the western slope of the Warner Range, flows in a southwesterly direction through several high valleys, where its flow is largely diverted for irrigation, enters narrow gorges in the Sierras, and joins the Sacramento about 10 miles above Redding. Its drainage basin is volcanic and contains many large springs which give it a constant flow of considerable volume throughout the year. Its principal tributaries are the Fall and McCloud Rivers. The former is a short stream coming from the lava beds in the northeast corner of Shasta County, but it is fed by springs of large volume, and has a mean flow of approximately 1,500 cubic feet per second. The McCloud takes the drainage of the southern and eastern slopes of Mount Shasta and joins the Pitt a short distance before it reaches the Sacramento River. The peculiar feature of this portion of the State's hydrography consists in shallow lakes without visible outlets and numerous streams which enter the lava beds and disappear. This may account for the extensive springs and their large volume. The records of the United States Geological Survey gaging station near Red Bluff show that

the country above this point drained by the Sacramento, including the Pitt, furnishes more than 40 per cent of the mean flow of the entire Sacramento Basin.

The Feather River, with its tributaries, the Yuba and Bear Rivers, is the most important single branch of the Sacramento, receiving the drainage of a large portion of the Sierras in Plumas County. Its course is first to the southwest, but after emerging onto the floor of the valley at Oroville it turns south and almost parallels the Sacramento for a considerable distance. Its waters are diverted for irrigation to some extent. Among its well-known districts are the orange-growing sections of Oroville, Palermo, Thermalito, and large valley areas in Butte and Sutter Counties. The plant of the Great Western Power Co., the largest in the State, developing 165,500 horsepower, diverts water from this stream above Oroville.

The Yuba River has its source in the crest of the Sierras in Nevada and the northern part of Placer and Sierra Counties in California. It flows in a southwesterly direction, emerges into the valley near Smartsville, in Yuba County, and joins the Feather River at Marysville. Its water is diverted into the drainage basin of the Bear River to irrigate a large section of the foothill country along the Ogden route of the Southern Pacific. Some of the largest hydro-electric plants in the State are along its course.

Bear River is not as large nor as important as the Yuba, but drains a considerable portion of the lower Sierras, and forms part of the boundary line between Placer and Nevada Counties and between Yuba and Sutter Counties and Placer County. Its direction is principally westward, and emerging out of the foothills a few miles east of Wheatland it joins the Feather River at a point about 10 miles above the junction of the latter with the Sacramento.

The source of the American River covers the greater part of Placer and El Dorado Counties west of the crest of the Sierras. Flowing southwesterly, it emerges onto the plains at Folsom City and joins the Sacramento just north of Sacramento. The diversions from this river are not extensive except for power and mining purposes.

There are three creeks of considerable size on the western slope of the Sacramento Valley, namely, Stoney, Cache, and Putah. Stoney Creek rises in the northwest corner of Colusa County and the western part of Glenn County, flows north, then east, and enters the Sacramento about 5 miles west of Chico. A Government reclamation project, which will irrigate the lands surrounding Orland, is in course of construction on this stream. Cache Creek has its source in Clear Lake, which receives the drainage of a large portion of the eastern slope of the Coast Range in Lake County. It flows northeasterly and enters the Sacramento due east of Woodland. Storage on this stream by the utilization of Clear Lake will make this one of

the most important tributaries of the Sacramento for the irrigation of lands on the west bank of the latter stream. The Yolo County Consolidated Water Co. secures its supply from this stream for the irrigation of lands in Yolo County. Putah Creek rises in Lake County, flows southeasterly, and enters the Sacramento east of Dixon. Although the use made of its waters is not as important as the other two, its flow is considerable, and with proper development large areas in the lower western end of the Sacramento Valley could be irrigated from it.

SAN JOAQUIN RIVER DRAINAGE.

All of the main streams of this valley head in the Sierras, and very little of its flow comes from the Coast Range except in years of unusual rainfall. The hydrography of the valley is somewhat distinct from that of the Sacramento, as it receives its waters from a continuous high range, whose mean altitude is about 12,000 feet. Its main supply is furnished by numerous peaks in this range, more or less covered with snow throughout the year. Two peaks may be mentioned in particular as the source of its headwaters—Mount Whitney and Mount Lyell. This portion of the Sierras is principally of a granitic formation and is not as heavily timbered as the northern section. On account of the altitude of this section the flood flow of its rivers is later than that of the Sacramento, the mean maximum flow occurring in May and June. The streams of this section are also more torrential in character.

Including the Tulare Valley, already mentioned, the principal rivers of the San Joaquin Valley are Kern, Tule, Kaweah, Kings, San Joaquin, Merced, Tuolumne, Stanislaus, Calaveras, Mokelumne, and Consumnes.

The Kern River has its source on the western slope of the highest peak in the Sierras, close to the division line between Tulare and Inyo Counties. Its course is south until it emerges onto the plains near Bakersfield, where it changes to the southwest, and the flood waters of the river find their way through numerous sloughs and channels in what is known as Kern Delta into Buena Vista and Kern Lakes. Its waters are practically all appropriated for irrigating the valley lands in the region east of and along the old channel through which it formerly drained into Tulare Lake.

The Kaweah and Tule Rivers rise in Tulare County, west of a divide which separates their basins from that of the source of the Kern. Their drainage areas are less than the Kern, owing to the lower elevation of this divide. The Tule emerges on the plains at Portersville and the Kaweah at Exeter, both of these sections being

noted for their citrus orchards. The Kaweah is the more important river, as, after leaving the foothills, it forms a delta in which the irrigated areas near Visalia and Tulare are situated. Diversions from the Tule are made close to the foothills and little, if any, of its flow reaches the plains through its natural channel except in seasons of high water. Both rivers find an outlet into Tulare Lake by means of numerous sloughs.

The source of the Kings River is separated from that of the Kern River by a high divide in the northeastern corner of Tulare County and receives its waters from the crest of the Sierras north of this point; it flows southwesterly through canyons and gorges of more than passing interest, and debouches on the plains at a point a little north of east of Fresno, irrigating the largest artificially watered area in the State. As it approaches the trough of the valley it divides into numerous sloughs, some of which carry its waters to Tulare Lake, while others have an outlet in a northwesterly direction into Fresno Slough.

San Joaquin River rises on the southeastern slope of Mount Lyell and drains the western exposure of the Sierra divide in Madera County and the northeastern portion of Fresno County. Its course is first south, then southwest between Fresno and Madera Counties until it reaches the trough of the valley, then northwest until it enters Suisun Bay. Its waters are used to some extent for the irrigation of lands along its banks in Fresno, Madera, Merced, and Stanislaus Counties, but any extensive use of its flow is prevented by the riparian rights which are claimed.

The Merced River has its source on the western and southern slopes of Mount Lyell, very near that of San Joaquin, and receives the drainage of the high mountains in Madera and Mariposa Counties. It flows through the world-famous Yosemite Valley, and continues in a westerly direction to its junction with the San Joaquin, about due west of the city of Merced. Its waters are diverted for a large irrigation system in the vicinity of that city.

The Tuolumne River is included also in the Mount Lyell drainage, taking its water from the northern slope of that peak. Its direction is principally westward, joining the San Joaquin due west of Modesto. Its waters furnish irrigation to the Modesto and Turlock districts, formed under the State law of 1887.

The Stanislaus River drains a large portion of the western slope of the high Sierras in Tuolumne and Alpine Counties, flows in a southwesterly direction to its junction with the San Joaquin, about 5 miles below the Tuolumne. Some diversions are made from it for

irrigation, and two districts recently formed under the State law will take a considerable part of its waters in the future.

The Calaveras River is smaller than those enumerated already and does not extend back far enough to secure a continuous flow from the melting snows of the higher ranges. Its flows last into June and some years into July, after which time it is dry until October or November. Considerable quantities of water are carried during the winter, so that with storage it could be developed. Its course is principally west, and it enters the San Joaquin almost due west of Stockton.

The Mokelumne, with its tributary the Cosumnes, forms the balance of the Sierra drainage of the San Joaquin River, although its junction with the latter is in the swamp lands west of Stockton, where there are many sloughs formed by the Sacramento and the San Joaquin Rivers. The Cosumnes has its sources in Eldorado County, while the Mokelumne, rises in Eldorado, Amador, and Calaveras Counties. They join in the swamp land 5 miles due west of Galt and distribute their flow among the various sloughs. Diversion from either of these streams is small, although the Mokelumne furnishes water to the irrigated lands near Lodi.

OTHER STREAMS OF IMPORTANCE.

The Klamath River rises in Upper Klamath Lake, in Oregon, traverses a portion of southern Oregon, enters California, and discharges into the Pacific Ocean about 30 miles south of the State line, including about 10,000 square miles in its drainage basin within the confines of the State. A large portion of this is on the watersheds of Shasta and Scott Rivers, in Siskiyou County, and Trinity River, in Trinity and Humboldt Counties. Its drainage basin resembles that of the Pitt River and is largely lavatic. Large springs occur in the Shasta and Scott Rivers, and considerable irrigation is practiced in the valleys of these two streams, as well as along the Klamath, near where it enters the State.

The Eel River rises in Lake and Mendocino Counties, flows in a northwesterly direction, and discharges into the Pacific Ocean a few miles south of Eureka, in Humboldt County. It has a drainage area of about 3,600 square miles, and its waters could be used to some extent for irrigation in the narrow valleys which occur at intervals along its course. The lack of transportation facilities in this section at present, however, makes it a stock country almost entirely.

The Russian River rises in Mendocino County, flows south through the Sonoma Valley, and empties into the ocean about 50 miles north of San Francisco Bay. It has a drainage basin with an area of 1,500 square miles and includes a large part of the fertile Sonoma

Valley. Little or no use is made of its flow as the rainfall throughout this section is heavy and the necessity of irrigating orchards and vineyards has not been felt.

Pajaro River is formed by the junction of Llagas, Carnardero, and Pacheco Creeks in the southwest corner of Santa Clara County. It receives the drainage of the upper Santa Clara Valley, flows westward, and pours its waters into Monterey Bay near Watsonville, in Santa Cruz County. The San Benito is its principal tributary, and, although its flow is intermittent, it is used for irrigation to some extent in the neighborhood of Hollister.

Salinas River, the next stream of importance to the south, has a drainage area of 4,800 square miles, being the third largest drainage basin of the main streams in the State. It rises in San Luis Obispo County, covers the greater part of that county and Monterey County, flows north through a considerable valley of the same name, and finds its outlet in Monterey Bay, almost due west of the city of Salinas. Notwithstanding its large drainage area, its flow is torrential in character, carrying large volumes of water at intervals during the rainy season and being almost dry throughout the summer. Its course parallels the coast, but is separated therefrom by a high, rugged range of intercepting hills, which causes the rainfall to be quite light, especially in the lower reaches of the valley. A break in this high range, where Nacimento and San Antonio Creeks enter from the west, permits a greater precipitation in the upper stretches of this stream, from which section the large floods come. An important tributary is the Arroyo Seco, joining the main stream near Soledad and heading in the high western ridge. This is the only branch which comes near to having a continuous flow throughout the year. This valley is unusually fertile and capable of high development under irrigation if its storage facilities were developed to conserve the large volumes which are now wasted during the rainy season. The greater part of the present irrigated area secures its supply from wells and pumping plants.

The next streams susceptible of development for irrigation purposes continuing along the coast are the Santa Maria, Santa Ynez, and Ventura Rivers, which, like the Salinas and other southern coast streams, are torrential in character in times of heavy and continuous rains and dry during the summer months. Their flow is used to some extent, but is uncertain. The Santa Maria flows between San Luis Obispo and Santa Barbara Counties, has a drainage area of 1,800 square miles, and empties into the ocean near Guadalupe. There is a considerable expanse of fertile land along it near the coast. The Santa Ynez is entirely in Santa Barbara County, and has a drain-

age area of 850 square miles. Its course parallels the southern coast boundary of this county, from which it is separated by a range of hills. A narrow border of valley land exists along its course, while in the neighborhood of Lompoc, near its mouth, there are fields of considerable extent devoted to bean culture principally. The Ventura, in Ventura County, drains the Ojai and Santa Ana Valleys and enters the ocean at the town of Ventura, and has a drainage area of 300 square miles.

The Santa Clara River is the second largest stream of the southern coast, and has a watershed of about 1,600 square miles. Its source is on the western slope of the high ridge which separates the Mohave Desert from the coast. Flowing in a westerly direction, it enters the valley and discharges into the ocean near Montalvo. Along its course are the irrigated sections of Piru, Fillmore, Saticoy, and Santa Paula, while the plains near its mouth depend largely upon pumping plants.

The Santa Ana, in San Bernardino, Riverside, and Orange Counties, has a drainage area of 1,600 square miles and is the most important stream in southern California. Its source is among the high peaks of the San Bernardino Range, from which it flows in a westerly and southwesterly direction to the ocean, finding its outlet near Newport Beach, a few miles southwest of the town of Santa Ana. Along its course are the well-known citrus-growing sections of Redlands, San Bernardino, Colton, Riverside, Anaheim, and Santa Ana, to all of which it supplies irrigation water to some extent. Its flow is augmented by the Bear Valley and Baldwin reservoirs in the mountains near its source.

The San Jacinto River rises in Riverside County and drains an area of 1,000 square miles. This river may be considered a tributary of the Santa Ana. Its waters flow into Lake Elsinore and thence northward by way of Temescal Creek into the Santa Ana. Near its source is the Hemet reservoir. Among its prominent irrigated districts are the San Jacinto and Perris Valleys, Elsinore, and Corona.

Between the Santa Ana and Santa Clara Rivers are the Los Angeles and San Gabriel Rivers, both of some importance, although not so large as the others, while farther down the coast the Santa Margarita, San Luis Rey, San Diegito, San Diego, Sweetwater, Otay, and Tia Juana are found in the order named. They are all small and of intermittent flow, but used largely to irrigate the valuable citrus-growing sections. Only the more important ones need description.

The San Gabriel rises in the San Gabriel Forest Reserve near the crest of the San Bernardino Mountains, flows south, entering the valley near Azusa, and irrigates the Duarte, Azusa, Covina, and Glendora lands. Its course continues south and then southeast to San

Pedro Bay, but little or none of its flow reaches the ocean except during high water. Its drainage basin covers 512 square miles.

The Los Angeles River is formed by a number of creeks in the San Fernando Valley and has a drainage basin of 470 square miles. It flows east, then south through the city of Los Angeles, and enters San Pedro Bay near Long Beach. Glendale, Burbank, and Tropico are along its course, while a tributary, the Arroyo Seco, drains the country surrounding Pasadena. Los Angeles obtains a part of its water supply from this stream. Its waters were used in the early history of the State to irrigate the lands around the San Fernando Mission.

The San Luis Rey River rises in the San Jacinto Forest Reserve, flows east, then southeast to the ocean at Oceanside. Its drainage area is 566 square miles. Water is diverted from this stream into Escondido Creek to irrigate the lands surrounding Escondido. Originally these lands were included in an irrigation district formed under the State law of 1887, but this district has long been defunct, and its bonds were settled at a loss to the holders.

San Diego River heads in the San Jacinto Forest Reserve near Santa Ysabel and flows southeast into San Diego Bay. Its waters are controlled by the San Diego Flume Co., irrigating lands north and east of San Diego. The Cayamaca reservoir is near its headwaters. Its drainage area is 409 square miles.

Sweetwater River rises a short distance to the south of the Cayamaca Reservoir, flows southeast, and enters San Diego Bay below National City. The well-known Sweetwater Reservoir is about 10 miles above its mouth. Water is furnished to the lands near National City. Its drainage area is about 220 square miles.

The Colorado River is the division line between California and Arizona. This stream drains a large portion of the country between the crests of the Rockies and the Sierra Nevadas, and may be said to collect the waters of portions of five States and two Territories, namely, Wyoming, Utah, Colorado, Nevada, California, Arizona, and New Mexico. Its waters have turned the desert lands of Imperial County into fertile fields, and more of this desert land is to be reclaimed in California by means of the Yuma project of the United States Reclamation Service. Its maximum flow occurs in May, June, and July, so that it furnishes an abundant supply at the proper time for irrigation.

Between the crest of the Sierras and the State line going north from the Colorado there are three rivers of moderate size—the Mohave, Owens, and Susan. The first is in the Mohave Desert, which covers a large part of San Bernardino County. This river rises on the northern slope of the San Bernardino Range and flows north,

then east. Its flow is small and intermittent, except in the early spring of wet seasons, when it carries large volumes for a few days. Its waters after reaching the desert are soon lost in the sandy soil.

The Owens River secures its supply from the high Sierras which form the western boundary of Owens Valley in Mono and Inyo Counties and is fed by the perpetual snows which cover Mount Whitney and the peaks to the north, so that a continuous flow is assured. It rises in the southern portion of Mono County, flows southward, and empties into Owens Lake. Its drainage area covers 2,600 square miles, but no water is produced on the barren mountains which line its eastern confines. Irrigation in connection with stock raising has been practiced here for a considerable period, principally near Bishop, but the isolated position of this valley has made development slow. A large part of its waters has been appropriated for the municipal supply of Los Angeles, and that still available for irrigation is limited, unless storage is resorted to.

The Honey Lake drainage, in Lassen County, of which the Susan is the principal river, is much smaller than the one just described, although its hydrography is similar. The Susan River rises on the eastern slope of the Sierras, flows east into Honey Lake, which is a sink for all streams in the drainage basin. The area of the watershed is placed at 1,650 square miles. The valley, although small, is fertile, and development is far greater than in the Owens River Valley, although its position is fully as isolated.

The following table, compiled from the bulletins of the United States Geological Survey,[1] gives a record of the flow of the various streams enumerated above, as far as could be obtained.

[1] U. S. Geol. Survey Irrig. and Water Supply Papers Nos. 81, 85, 100, 134, 135, 176, 177, 212, 213, 250, 251, and 253.

Table showing drainage areas in square miles, mean monthly, average annual, and maximum and minimum flow in cubic feet per second of streams in California.

Stream and point of measurement.	Number of years.	Drainage area.		Mean flow.												Average yearly mean.	Maximum flow.	Minimum flow.
		Entire stream.	Above point of measurement.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.			
Sacramento Valley:																		
American River, Fairoaks	4	2,000	1,899	4,232	6,762	11,960	10,146	11,304	8,252	3,289	701	315	340	456	1,523	4,945	100,000	105
Feather River, Oroville	7	3,654	3,350	7,242	14,476	20,164	18,504	13,743	7,972	3,209	1,859	1,599	1,973	4,747	4,685	8,347	129,000	1,200
Yuba River, Smartsville	5	1,358	1,220	4,751	8,244	11,320	8,812	8,676	5,536	1,810	575	484	749	672	1,865	4,457	100,000	380
Bear River, Wheatland	2	287	.....	2,094	1,237	2,635	983	742	418	75	32	32	30	57	905	770	21,400	10
McCloud River, Gregory	5	676	608	2,753	3,915	5,431	3,597	2,628	2,146	1,568	1,443	1,398	1,629	1,847	1,755	2,509	28,500	1,282
Pitt River, Bieber	4	4,597	2,948	1,033	2,788	5,068	2,679	1,421	837	192	41	23	64	183	389	1,227	27,500	1.5
Sacramento River, Red Bluff[1]	13	27,500	9,300	20,243	28,316	30,522	19,856	14,606	9,365	6,091	5,118	4,975	5,815	9,836	12,409	13,929	195,000	3,630
Stoney Creek, Juliens Ranch	7	760	760	1,369	2,441	2,656	1,190	524	205	44	15	13	54	355	498	780	26,500	0
Cache Creek, Lower Lake	8	1,192	500	496	848	1,799	1,529	839	507	318	183	97	69	84	132	575	19,200	12
Putah Creek, Winters	3	606	91	2,076	1,526	2,957	726	235	135	40	14	12	12	22	390	678	30,000	4
San Joaquin Valley:																		
Cosumnes River, Live Oak[2]	6	580	580	581	975	1,058	2,552	3,298	3,186	769	227	47	71	80	247	1,080	6,090	12
Mokelumne River, Clements	5	657	537	651	1,465	2,759	2,968	3,756	3,455	1,602	280	180	310	318	530	1,523	15,300	43
Kern River, Bakersfield[3]	19	2,345	2,345	466	569	879	1,468	2,189	2,166	1,227	542	322	309	319	366	902	.....	.....
Tule River, Portersville	12	437	437	188	253	456	568	625	410	165	58	36	41	56	96	246	4,615	7
Kaweah River, Three Rivers	5	619	520	319	466	1,052	1,283	1,897	1,941	1,032	244	127	177	92	141	731	8,180	40
Kings River, Red Mountain	13	1,742	1,742	1,175	1,133	2,246	3,889	7,714	8,207	3,715	1,145	436	471	509	535	2,598	43,930	130
San Joaquin River, Herndon	8	30,500	1,637	1,674	1,795	2,400	4,039	7,402	7,179	2,607	1,028	439	364	702	705	2,526	59,800	69
Merced River, Merced Falls	7	1,076	1,076	898	1,122	2,931	2,993	4,561	4,052	1,871	434	147	327	218	326	1,665	27,500	0
Tuolumne River, La Grange	13	1,501	1,500	1,563	2,528	4,852	5,214	7,560	7,308	2,957	605	213	526	835	958	2,926	52,000	0
Stanislaus River, Knights Ferry	10	1,051	1,000	1,049	1,766	3,463	3,943	5,012	3,894	1,488	361	178	304	428	586	1,873	57,200	25
Calaveras River, Bellota	5	491	491	552	915	1,024	1,709	1,054	162	19	2	0	54	34	2	472	4,174	0

Other streams:																		
Klamath River, Keno, Oreg	4	.....	.....	2,309	2,741	3,063	3,467	3,393	2,834	1,975	1,304	1,116	1,234	1,496	1,753	2,223	5,240	1,050
Santa Ynez River, Santa Barbara	2	836	207	45	466	924	140	60	20	5	2	1	1	2	28	142	7,275	0
Santa Ava River, Mentone	12	1,540	182	60	98	169	147	96	69	59	52	48	46	48	38	78	4,908	17
San Gabriel River, Azusa	13	512	222	137	228	524	270	162	81	45	27	22	28	41	43	134	11,130	3
San Luis Rey River, Palo	5	566	.....	129	102	377	119	67	26	6	4	3	8	12	25	73	13,000	1.5
San Diego River, Lakeside	3	409	.....	72	68	323	148	39	10	0.7	0.2	0	0	0	4	56	3,800	0
Cottonwood Creek, Barret Dam	2	499	.....	95	45	392	144	50	27	8	4	1	5	15	45	65	1,170	.....
Susan River, Susanville	3	256	256	65	223	356	443	342	95	28	17	13	18	59	36	141	1,750	7
Owens River, Round Valley	5	2,629	.....	204	225	292	247	317	495	509	360	260	236	220	215	296	1,190	146
Mohave River, Victorville	6	400	.....	76	244	259	179	66	40	35	37	41	49	72	59	96	13,413	17
Arroyo Seco River, Soledad	8	215	215	404	484	708	316	136	65	22	10	6	19	31	102	192	6,250	0
Colorado River, Yuma, Ariz	7	225,049	225,049	7,610	11,683	19,019	21,713	36,923	62,550	38,766	17,913	10,717	9,610	8,048	10,182	21,228	115,400	2,694

[1] Includes flow of Pitt and McCloud Rivers.
[2] State engineer's records and United States Geological Survey.
[3] Kern County Land Co.'s records and United States Geological Survey.

Regarding the flow of the Sacramento River, which is shown as the largest stream of the State, a recent paper read before the Society of Civil Engineers,[1] gives its estimated flood discharge during the high stage of March, 1907, as 640,000 cubic feet per second. Floods along this stream occur every few years and cause great damage, so that its control has been an important problem. Recent developments tend to show that a general plan for protection along its banks has at length been adopted, and with the aid of the Federal and State governments, as well as the landowners, there is every evidence that these unusually fertile lands will be saved eventually.

LAKES AND STORAGE FACILITIES.

Throughout the high Sierras, and particularly on their western slopes, lakes are numerous, and although none of them is of any appreciable size, they are usually of great depth. East of these mountains they are fewer in number, but much greater in extent. Several, however, are sinks without an outlet and their waters are strongly mineralized.

There are several good-sized lakes in the northeastern corner of the State, namely, Lower Klamath, Tule or Rhett, Clear, Goose, and Upper, Middle, and Lower Alkali Lakes. All of these are shallow and more or less alkaline, and are near the headwaters of the Klamath and Pitt Rivers. Although Tule, and Upper, Middle, and Lower Alkali Lakes are without apparent outlets, their waters are not so strongly mineralized as would be supposed, and it is possible that some of the large springs in this section are connected with them. Farther south in the Honey Lake drainage basin are two sheets of water of considerable extent, Eagle and Honey Lakes, neither of which has a visible outlet. The water of the former is sweet and that of the latter somewhat alkaline, resembling those described above.

South of these is Lake Tahoe, at an elevation of 6,000 feet, with a surface area of about 250 square miles, partly in California and partly in Nevada. It has an average depth of about 1,000 feet and is the source of the Truckee River. At present its waters are available only for the State of Nevada and are being used on the Truckee-Carson project of the United States Reclamation Service. Schemes for tapping this enormous supply by means of a tunnel through the Sierras and thus rendering them available for use in California have been broached, and with greater development of irrigation and electric power in the great interior valleys and the consequent scarcity of water such an enterprise might be feasible.

Farther down the State line are Mono and Owens Lakes, neither of which has an outlet. Their waters are strongly alkaline. Still farther south, near the Mexican border, is Salton Sea, formed by the

[1] Proc. American Soc. Civil Engineers, Feb., 1908, Vol. XXXIV, No. 2.

break in the Colorado River during 1906–7. It is 200 feet below sea level and covers an area of about 350 square miles. Its extent is gradually diminishing, although it receives the waste water from the irrigated lands of the Imperial Valley. Its area will be reduced greatly, providing no further overflows from the Colorado occur, and it will reach a stage eventually where the great evaporation from its surface will be compensated for by the drainage and waste waters of its neighboring irrigation systems. Its waters contain considerable salt and with the continued decrease in its area it will be strongly mineralized.

Tulare and Buena Vista Lakes cover a considerable area west of the Sierras in the southern end of the great central plains. The former, which receives the waters of Kings, Kaweah, and Tule Rivers, was formerly of much greater size and in times of high water discharged its surplus into the San Joaquin River by means of Fresno Slough. Since so much water has been diverted from these three streams for irrigation the lake has receded until large areas which were formerly covered are now converted into valuable farming lands. These lands are still subject to overflow in wet years, however, and at the present time (1909) are largely under water.

Buena Vista Lake, which is the outlet of Kern River, is connected with Tulare Lake by sloughs through which its floods finally reach the San Joaquin River. Its value as a storage reservoir for lands to the north and northwest of it was recognized early and it is now used by the Kern Valley Irrigation Company for storing the flood waters of the Kern River.

Clear Lake, in Lake County, is the only natural body of sweet water in the Coast Range worthy of consideration. It is on the eastern slope of the mountains and has a surface area of 64 square miles. It is the source of Cache Creek, which flows eastwardly and enters the Sacramento River near Woodland, about 10 miles north of the city of Sacramento.

California has been very backward in the storage of water for irrigation. Reservoirs do not exist to any extent, except in the southern part of the State, where the flow of the streams is very uncertain. A perusal of the records of the United States Geological Survey will show that their absence is not due to a lack of suitable sites nor to a sufficient supply of water throughout the year, as it happens frequently in years of light rainfall that the supply is cut off when most needed. Their absence must be attributed, therefore, to the peculiar condition of the State laws.

UNDERGROUND SUPPLY.

None of the States in which irrigation is practiced can show such favorable conditions for tapping the subsurface water supply and

securing as adequate a flow as California, and the area irrigated from pumping plants and artesian wells in California is far greater than that in the balance of the arid States. Not only is artesian water found at shallower depths, but as a rule the subsurface table of nonflowing wells is within close proximity to the surface, and can be drawn on for large quantities. The artesian belts are distributed throughout the valleys of the State, and the water from these wells is generally pure and of good volume. The United States Geological Survey has prepared reports covering in part the location of these wells.[1] Among the more important districts in which flowing wells are found are the coastal region of southern California, Coachella Valley, the trough of the San Joaquin Valley, the valleys along the southern part of San Francisco Bay, and Surprise Valley in Modoc County. Pumped wells used for irrigation are common in the coast region of southern California and the San Joaquin, Sacramento, Salinas, and Santa Clara Valleys. Although at present the use of the summer flow of various streams throughout the irrigable sections, with the possible exception of the Sacramento Valley, is very extensive, there is unquestionably a much larger use possible if storage is resorted to and if the irrigation laws of the State are placed on a basis where there would be some definite information regarding the use of water. The large area irrigated from pumping plants is due to quarrels, litigations, and poor management of the gravity systems. The farmer owning his own pumping plant is entirely independent of his neighbors and can obtain his supply whenever necessary without consulting any one or fighting with those who divert water above him.

LANDS.

The land surface of the State is placed at 99,898,880 acres, the greater part of which is a rough, mountainous country and desert. To specify more particularly, it may be divided, roughly, as follows:

Classification of lands.

	Acres.
Arable areas:	
Swamp lands reclaimed and possible of reclamation	2,500,000
Valley lands	13,500,000
Hill and rolling lands	4,000,000
Total	20,000,000
Forest, grazing, and mineral lands:	
In Government reserves	25,000,000
In private ownership	35,000,000
Total	60,000,000
Waste lands: Bare mountain ranges and desert	20,000,000

[1] U. S. Geol. Survey Water Supply and Irrigation Papers Nos. 57, 149, 219.

The arable area therefore is about one-fifth of the total area of the State, but nearly equal in area to the State of Indiana. Nearly two-thirds of the valley lands, including swamp and overflow lands, are included in the great central plains—Sacramento and San Joaquin Valleys. The balance is along the various independent streams, as follows:

Distribution of arable area.

	Acres.
Great central plains	10,000,000
Imperial, Coachella, and Colorado River Valleys	500,000
Southern coast valleys, including Santa Maria Valley	1,000,000
Salinas, Pajaro, Santa Clara, Livermore, Sonoma, Napa, and San Francisco Bay Valleys	3,000,000
Mohave, Owens, Honey Lake, Klamath Valleys and the northern region	1,500,000
Total	16,000,000
Rolling land:	
Coast range	2,500,000
Sierra Nevada Mountains and balance of State	1,500,000

Approximately one-half of the land surface of the State is under control of the United States Government, including 25,000,000 acres in forest reserves, and about an equal amount in public domain.

The advent of the Franciscan fathers and the establishment of their missions along the coast from San Diego to Sonoma was the first step in the civilization as well as the agricultural development of the State. In the old gardens, many of which may yet be seen surrounding the missions, fruits of all kinds were grown, many of such excellent quality that they have become popular commercial varieties under the names of Mission fig, Mission grape, Mission olive, etc.

To induce settlement, the Spanish Government—and later the Mexican—made large land grants to individual settlers, extending at first along the coast and later into the valleys. These grants were used as cattle ranches exclusively, and up to the time of American occupation the exports consisted entirely of hides and tallow. The grants covered the valleys of the State to a large extent, and later were recognized and patented by the United States Government. About 500 of these claims, covering nearly 9,000,000 acres, were found to be valid. The railroads were aided also in the early period of statehood by very large grants of farming land. All swamp and overflow areas were transferred by the Government to State control, so that little public land, outside of the desert and mountainous regions, was open to homestead entry.

Less than one-half of the total arable area is at present in cultivation, that requiring irrigation being confined to the interior valleys and the southern coast. From San Francisco northward the heavy rains and the summer fogs make this artificial application of water

to the soil unnecessary in those sections which feel the direct effect of the winds from the ocean.

The existing irrigation systems cover about 4,000,000 acres, one-tenth of which is served by pumping plants and artesian wells and the balance from stream diversions. These include the valley lands along the coast from the Mexican border to and including Ventura County; the Imperial and Coachella Valleys in the Colorado Desert; a few isolated areas in the western portion of the Mohave Desert; the Santa Maria, Owens, Salinas, Pajaro, Santa Clara, and Honey Lake Valleys; an extensive area east of the trough of the San Joaquin Valley, with a narrow strip on the west bank of the San Joaquin River; scattered areas throughout the Sacramento Valley, and some patches along the upper Pitt, Scott, Shasta, and Klamath Rivers. The character of the soil varies greatly, but its depth and productive value for a great variety of crops is universal. Values for irrigated land depend largely upon the locality. In southern California, where water is scarce and its use controlled carefully, as high as $3,000 per acre has been paid for bearing orange and lemon orchards, while unimproved lands are worth $150 to $200 per acre. In other sections of the State, where there are lesser restrictions on the supply and its use, $50 to $150 per acre for unimproved and $200 to $1,000 per acre for bearing orchards or vineyards would be approximately the ruling rates.

PRODUCTS.

The range of economic plants and trees to which the soil and climate of California are adapted covers practically every product of the Temperate and sub-Tropic zones and a few of the more hardy tropical plants. The great influx of people occasioned by the discovery of gold in 1848 and the consequent high values of fodder and produce directed the attention of the farseeing among the early pioneers to agricultural pursuits. Their phenomenal success and the large yields of cereals, for which there was the greatest demand, turned the valleys into waving grain fields, each farmer controlling a small principality. Farming on such an immense scale and with boom prices was very profitable from the late fifties to the early eighties. The grain was planted in the fall, and there being no cold weather to retard its growth during the rainy season, it was ready to harvest in the early summer and did not require irrigation. The continued growing of one crop on the same piece of ground and the gradual decline in prices, however, could have but one result. Meanwhile small orchards and vineyards, as well as products raised by irrigation on limited areas, pointed the way to more profitable and secure pursuits, and irrigation for fruit growing and other valuable crops may be said to date from this period.

The coast region of southern California first felt the change in its agricultural condition. This was due largely to the examples set by the mission gardens planted by the padres soon after their advent. These orchards contained citrus fruits, vines, olives, figs, and a variety of the more hardy deciduous trees, all of which flourished with little or no attention and produced fruits of fine quality. The mild climate and attractive orange groves were especially conducive to dense settlement by people from the harsher climate of the Eastern States, so that this section became early the home of the orange, lemon, olive, and walnut.

In the San Joaquin Valley the building of the Central Pacific Railroad, which furnished transportation facilities for its products, was the precursor of irrigation development. The light rainfall, combined with hot, dry summers, precluded the growing of most crops without irrigation, so that farming crops outside of the cereals may be said to date from the opening of the irrigation systems.

The Sacramento Valley, which was the scene of the gold fever and through which the overland trail led, became at an early date the granary of the State. The operations conducted on such large areas with a soil of unusual depth and fertility, made this the stronghold of grain farming. It still holds this claim, although at present it is being converted rapidly into irrigated lands. This section will doubtless see the greatest development of irrigation in the near future, as its entire surface can be covered by canals and ditches diverting water from its streams without affecting their navigability.

Although crops of almost every kind are produced throughout the agricultural sections of the State, many localities are famous for certain varieties. Oranges and citrus fruits are found principally in the coast region of southern California and in the lower foothills of the Sierras. The latter section, known as the Thermal Belt, permits the commercial growing of these somewhat tender fruits almost within the shadow of Mount Shasta at the head of the Sacramento Valley. Southern California and the great interior plains seem adapted also to olive culture, and California is the only State producing olive oil and pickled olives in commercial quantities. Other products, of which certain localities are famous, are walnuts in southern California, raisins in Fresno County, prunes in Santa Clara County, wine grapes in Napa and Sonoma Valleys, almonds in Contra Costa and Yolo Counties, asparagus and potatoes on the reclaimed swamp lands of the lower Sacramento and San Joaquin Valleys, and celery near Santa Ana. Deciduous fruits, berries, alfalfa, sugar beets, and a great variety of vegetables and melons are grown quite generally throughout the State. The canning, drying, and green shipping of fruits and vegetables, as well as the making of wines and brandies, offer numerous uses to which all products can be put and

an unusual field for their exploitation. The climate is unusually favorable for the drying of fruits, owing to the long, hot, rainless summers which permit of the use of the sun's rays alone. The areas devoted to various crops are approximately as follows:

Acreage of various crops.

	Acres.
Orchards	500,000
Vineyards	400,000
Alfalfa	350,000
Sugar beets	65,000
Vegetables, small fruits, etc	200,000
Grain, hay, grass, etc	6,485,000
Total	8,000,000

Dairying has become of great importance in late years, especially where irrigation is practiced in raising alfalfa. The State Dairy Bureau shows a production of 44,600,000 pounds of butter and 6,000,000 pounds of cheese for the year October, 1906, to October, 1907. The modern creamery methods, whereby the mechanical separators are used and the skimmed milk returned to the farmers, make it possible to combine hog and poultry raising with the dairy industry and give good returns.

Another industry which is attracting a good deal of attention at the present time is the culture of eucalypts. These trees are natives of Australia and do remarkably well in the mild climate of this State. They are of unusually rapid growth and will stand heavy cutting without affecting their vitality. The wood of many species is hard and shows greater strength than either hickory, oak, or ash. Large plantings are in prospect, especially throughout the irrigated sections. Its use for firewood, poles, piles, ties, furniture, lumber, tool handles, as well as for medicinal purposes, makes its culture very attractive.

Seed men have also given the State prominence. Vegetable and flower seeds are produced in very large quantities and find a market throughout all civilized countries. A climate which permits of the growing of the hardy conifers of the far north alongside of the palms, bananas, and citrus fruits of the Tropics, represents in no small degree the possibilities of this unusually favored region. A comparison of the products of the irrigated and unirrigated sections gives a decided advantage to the former. As a specific instance, the large fruit-growing interests of Santa Clara County may be mentioned. In the boom days of 1889 to 1891 one of the greatest arguments of the real estate men of this county was that no irrigation was needed, and therefore their section of the State had a decided advantage over the irrigated portions. Since then, however, pumping plants and stream diversions have been increasing in use, so that

at the present time the greater proportion of improved orchard land receives irrigation with a great increase of the profits from the orchards. Similar experiences have been had in the Sacramento Valley, so that the greater part of the tilled area, with the exception of that devoted to cereals, is now irrigated. The value of farm products as shown already was over $250,000,000 for the year 1907.

HISTORY OF IRRIGATION DEVELOPMENT.

The establishment of the San Diego Mission in 1769 served as the first step in the introduction of irrigation in California as well as in its civilization. The padres, who were mostly Spaniards, were more or less familiar with this system of agriculture in their native land, and their knowledge had been enhanced by their experience in the arid climate of Lower California. As soon, therefore, as their settlement was well started arrangements were made to secure a water supply to irrigate their gardens and orchards. With the abandonment of the missions their irrigation systems fell into disuse, and, with the possible exception of the stone dam constructed at Santa Barbara Mission, which is at present incorporated in the municipal works of that city, their ruins may still be seen near by. That irrigation was practiced outside of the mission gardens during this period is shown by a controversy over the use of water between Manuel Nieto and the San Gabriel Mission, which was settled by the Spanish governor, Borica, in 1796.[1]

With the independence of Mexico more liberal laws were enacted regarding land grants, which had been previously confined to officials of the Spanish Government. These laws were designed to encourage settlement, and provided for home seekers, whether citizens or not, various sizes of grants, as follows: One square league of irrigable land, 4 square leagues of tillable land, and 6 square leagues of grazing land.[2]

In accordance therewith colonists were required to improve these lands within a specified time or forfeit their rights. The minimum amount to be improved during that period was prescribed as 200 varas[3] square of irrigable, 800 varas square of cultivated, and 1,200 varas square of grazing land, while house lots were fixed at 100 varas square. This resulted in the immigration of a large number of people, many of whom were Americans. The rebellion of these settlers against Mexican rule and the cession after the Mexican War of what is now the southwestern part of the United States followed. The cattle and stock industries were dominant up to 1848. The discovery

[1] Hittel's History of California.
[2] Hittel's History of California. (Square league equals 4,428.4 acres.)
[3] Vara equals 2.78 feet.

of gold and the influx of seekers after this precious metal increased the population of the State tremendously. Agriculture, as well as all other industries, gave way to mining, but after the exhaustion of the upper crust of the rich placer deposits more normal conditions returned. Grain farming and stock raising became the chief occupations, and during a long period California was the chief wheat, barley, and wool producing State of the Union. Irrigation during this period was confined to a few isolated sections, among which may be mentioned diversions from old mining ditches in the Sierra foothills from the Tuolumne River to the Feather River, the Moore ditch diverting water from Cache Creek in Yolo County, a few patches along Kern, Kaweah, Kings, San Joaquin, and Stanislaus Rivers, and on the Santa Ana, San Gabriel, and Los Angeles Rivers of southern California.

The extensive development of irrigation in California may be said to date from 1869 and 1870, when the Central Pacific extended its road throughout the San Joaquin Valley. The first large system was the San Joaquin and Kings River Canal & Irrigation Co., which diverted water in 1871 from the San Joaquin River at the point where its course turns to the north. This canal extends along the west bank of the river and was first constructed as far as Los Banos Creek, a distance of 40 miles. This was followed by extensive canal construction in Fresno, Tulare, Kern, Los Angeles, San Bernardino, and San Diego Counties, so that when the report of the State engineer appeared in 1880 there were 292,885 acres in Los Angeles and San Bernardino Counties and the Sacramento and San Joaquin Valleys, and probably 350,000 acres irrigated in the State. The greater part of the lands thus watered was devoted to cereals, a considerable acreage was in alfalfa, and the balance in orchards and gardens. About 1880 the fruit industry began to assume importance, and from this time up to 1893 irrigated agriculture received its greatest impetus. Up to 1887 all development was made by private enterprise, but an act of the State legislature in that year, known as the Wright law, permitted the organization and bonding of districts by vote of residents within the district boundaries. The purpose of this act was to provide some relief from the many conflicting interests of the private and uncontrolled ownership of canal systems, from which the State was suffering even at that period. The popularity and the immediate advantage taken of this law is shown in a bulletin of the Bureau of the Census,[1] which contains a list of 50 districts, including about 3,000,000 acres, and entailing a bond issue of about $27,500,000.

[1] U. S. Dept. Interior, Bur. Census, Report on Agriculture by Irrigation, 11th Census, p. 38.

A number of these organizations, however, had in view the purchase and consolidation of existing systems, so the large acreage shown did not represent that much increase in the irrigated areas. The districts being incorporations of a public character, provisions should have been made for their strict control by the State authorities, but instead the office of State engineer was abolished about that time, leaving no one with the necessary experience and general knowledge to whom the control could be confided. The matter was left entirely to the district organizations, and resulted in a complete failure of most of the districts, so that at the present writing only 4 of the original 50 are in existence. This provision, which would have meant so much to the State's development, failed of its purpose on account of controversies between the small landowners who favored it and the large landowners who were opposed to it, as well as to poor management, poor legal and engineering advice, and a general misunderstanding of the State's complicated irrigation laws. If its execution had been left in the hands of a competent State engineer, thus placing the State government back of the approved projects, there probably would have been no trouble in disposing of the bond issues to large banking interests.

In 1897 the Wright law was amended and superseded by the Bridgeford Act, which, although it did not alter the original law in its general form, made such correction and improvements as were necessary to help out the districts which were still in existence.

The poor success which attended the districts put a damper on any further development along those lines, but with the final successful outcome of those remaining, especially the Modesto and Turlock districts, this matter is being broached again, with the prospect that there will be a number of new organizations within the next few years.

It is quite remarkable that with the recommendations of various commissions regarding the needs of a code of laws which would define and control the water resources of the State, no legislation has ever been enacted which would place this, its most valuable possession, on anything like a systematic or organized basis. Probably the first report along these lines was that of a commission appointed by the United States Government to investigate irrigation in the great central plains in 1873.[1] The recommendations in the concluding chapter of that report, from which the following extracts have been taken, are a tribute to the foresightedness of the members of that commission, in predicting what would happen unless the State exercised control over its streams.

SEC. 22. That when any canals are built, the State should establish a system of inspection by which a proper construction shall be assured; that the quan-

[1] Ex. Doc. 290, 1st Session, 43d Congress.

tity of water to be taken from a river at its mean stage, for the irrigation of a definite quantity of land, should be fixed by a reasonable rule, so that those who come later shall not find all the water taken up, and so that proper drainage shall be secured.

That such supervision will probably be distasteful to the parties concerned; that, nevertheless, we believe it is essential to future prosperity, and *that its neglect now will bring a fruitful crop of contentions in the future,* will delay the development of the country, and that by making irrigation unhealthful it may make it odious.

The report of the State engineer for 1880, which has been referred to already, made very strong recommendations also as to a revision of the then existing laws. Many of his ideas have since been incorporated in the State laws of Wyoming. His proposed remedies came under two heads:

First. By the passage of a law entitled "An act to define and regulate water rights."

(1) Institute proceedings to define for record the extent and nature of all existing water privileges.

(2) Provide for a proper record of existing rights and for an annual correction of same to date.

(3) Provide for the issue of water privileges in proportion to the supply of water in each stream and designate by schedule the extent and order of each claim.

(4) Supervise in a general way the distribution of water from the stream or natural source of supply to those holding water privileges.

(5) Establish a definite standard of measure for water used for agricultural and mining purposes and prescribe the form and dimension of measuring apparatus to be employed in dealing out water under different circumstances.

Second. By the passage of a law entitled "An act to promote irrigation."

(1) Provide for the organization of irrigation districts from time to time, according to the natural divisions of the land, as near as may be in each instance.

(2) Provide for the internal self-government of each district by the residents thereof.

(3) Provide for the allotment of permanent water privileges to such districts.

(4) Provide for the condemnation of private water rights for the public use in the case of rights acquired to waters from public streams for lands within such districts.

(5) Provide for the adjustment of riparian rights in each instance where a water privilege is granted to a regularly organized district, so that the riparian proprietors will be insured sufficient water for domestic and stock purposes, the district to be held liable for its share of the expense of meeting this obligation and the State undertake its adjustment.

(6) Provide for the protection of river navigation by regulating the diversions of water from navigable rivers and their tributaries, so that in some certain period the water may be used for irrigation and in some other periods they may be allowed to flow in the streams for the benefit of commerce.

(7) Provide for the total extinguishment of rights where unadjustable conflicts occur.

(8) Carry on such observations as will detect the locality and cause of waste of each in each instance; conduct experiments with the view of discovering the

most economic means of distributing and using water in irrigation without material loss or waste.

(9) Establish general regulations from time to time for the distribution of water in irrigation which will prevent waste, insure good drainage, and guard against the unhealthful tendency of the careless and vicious use of water in irrigation.

Of these recommendations but two are in effect—that regarding the formation of irrigation districts, as evidenced by the Wright and Bridgford acts referred to already, and the study of irrigated conditions to discover the most economical means of use and distribution of water in irrigation. The latter has been carried on during the past eight years by a cooperative arrangement between the Office of Experiment Stations of the United States Department of Agriculture and the State, while gagings of the various streams, analyses of waters, and topographical surveys are being made under a similar agreement with the United States Geological Survey.

In 1900 the Office of Experiment Stations published an elaborate bulletin on irrigation in California,[1] which took up the subject of the use and control of its water resources and by actual investigations of a number of the streams on which irrigation was an important feature, showed the condition of water rights and the endless litigations which ensued, owing to unrestricted appropriations. It was shown in nearly every case that diversions claimed by individuals and companies enormously exceeded the mean annual flow of the stream, while some claims were so worded that it was simply impossible to understand what was meant. Although the code provides that the quantity of water shall be restricted to beneficial use and that work shall commence within a definite period, "beneficial use" was not defined and no one was intrusted with the supervision of diversions to see that the provisions of the law were carried out, with the result that not only claims to various quantities, but the priorities of such claims, have been fought out continuously in court. The law further provides that after posting a notice of diversion the same should be recorded in the records of the county in which the point of diversion is, within 10 days after posting the notice. On a stream flowing through several counties there was the possibility of rights being claimed in each for the entire flow of the stream, as no general record was available whereby the appropriator could find out what diversions had been made in the other counties except by examination of records in each county. This was further complicated, however, by a provision allowing an appropriator, who had fulfilled the letter of the law, without recording, and whose use of water was unquestioned, a title to his diversion. On top of all this, the recognition of riparian rights in accordance with the common law of England placed irrigation

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 100.

matters in such a state that it may be said safely that sufficient money had been spent in litigation to have constructed a complete and perfect distributory system of water to every irrigable acre in the State. These litigations have not assisted in leading to any definite definition of the law and most of them have been settled by compromise, which, although they brought about an adjustment between litigants, did not affect new appropriators, who would disturb the compromise and start more litigation.

As a result of these conditions many of the larger irrigation systems have been consolidated, more or less, and are in the hands of strong corporations, who sell the water, but own no lands. This kind of monopoly has not resulted in exorbitant charges for water, owing to a provision of the law placing the power to fix annual rates with the board of supervisors of each county. These rates have been reasonably low, and are on a per acre basis, as a rule, without specifying the quantity. This has led to a very wasteful use of water on most of the systems, with the exception of those in southern California, two systems in the San Joaquin Valley, and the irrigated foothill lands of Placer County. The scarcity of water and the expensive construction necessary to prevent loss in delivery in the coast region of southern California made it absolutely necessary to measure the water to the users and charge for it accordingly, and, as a result, this section shows the highest duty in the United States, and the methods of distributing and conserving the moisture after application to the soil are in general without equal.

The only portion of the State in which individual irrigators have appropriated waters and built their own systems, where litigations are rare, is on the Pitt River in Modoc County. Here harmony seems to reign, and the spirit of selfish individualism is unknown, although the flow is practically covered by the diversions. This condition is more or less true of the Klamath, and also its tributaries. Otherwise, controversies over the diversions from the natural watercourses of the State for mining, power, and irrigation have filled a large part of the court records.

WATER LAWS.

The legislature of 1850 made the common law of England the rule of decision in all courts of the State, so far as it was not repugnant to the Constitution of the United States or the constitution or laws of the State. The courts of the State have held that the common-law rule of riparian rights holds in the State, and that the United States, as the original and sole riparian owner, had unlimited right to do what it chose with the streams. This gave rise to what is known as the California doctrine as opposed to the so-called Colorado doctrine held by many of the Western States, which rejects the common law of riparian rights entirely, as being unsuitable to western conditions.

A perusal of the statutes shows that the control of the streams was considered of greater importance in early days than later. A law passed in 1854 provided for the appointment of water commissioners in several counties, with overseers in each township to regulate and control the appropriations. This law seems to have remained in force until the late seventies, when its provisions were neglected, although the law was not repealed. The mistake in the law was that the right was given to each county instead of being vested in the State government.

Article XIV, section 1, of the constitution of the State declares the use of all appropriated waters to be a public use and subject to the regulation and control of the State. The acts of 1880 and 1885 and the several amendments to the latter gave the supervisors of the several counties authority to fix the rates annually for water sold for irrigation and provide penalties for charging rates in excess of the fixed rates. The first act also prohibits a person, company, or corporation from selling water for irrigation or exercising any control as to its use after it has been delivered. The act of 1885 and its amendments provided rules to govern the supervisors in fixing or changing a water rate. They also forbid any person, company, or corporation selling, renting, or distributing water to refuse to supply water to anyone demanding it and tendering the established rate, so long as the actual supply will permit it. The right to condemn land for right of way is granted any appropriator who has acquired a water right.

The civil code, sections 1410–1422, contains the following provisions as to the appropriation and use of water:

> Running water flowing down a river or stream or canyon or ravine may be acquired for a useful or beneficial purpose, and as between appropriators the first in time shall be the first in right.

The method of appropriation is as follows:

> The person desiring to appropriate water must post a notice in writing in a conspicuous place at the point of intended diversion, stating therein—
>
> (1) The flow claimed in miner's inches measured under a 4-inch pressure.
>
> (2) The intended use and the place of intended use.
>
> (3) The means intended to be used in diverting, and the size of the flume, ditch, pipe, etc., intended to be used.

The law requires that a copy of this notice be filed within 10 days after it is posted with the recorder in the county where posted, and there recorded in a book kept for that purpose. Within 60 days after posting the notice, the claimant must commence excavation or construction of the works and prosecute the work diligently and uninterruptedly to completion, unless temporarily interrupted by snows or rain. In case the erection of a dam has been recommended by the California débris commission, the claimant has 60 days after the com-

pletion of the dam in which to begin excavation or construction of the works. If necessary to bring proceedings in eminent domain to acquire water rights or sites, the claimants have 60 days after the determination of legal proceedings by final judgment in which to begin work, but it is provided also that such proceedings must be begun within 60 days after posting the notice of appropriation and must be prosecuted diligently to final judgment. In case the point of diversion or any part of the intended route of conveyance is on public land, the claimant has 60 days after authority has been granted to use such park or public reservation. Completion is defined to mean conducting the waters to the place of intended use.

If the claimant complies with the rules, his right relates back to the date when the notice was posted, but if he does not, he has no right as against subsequent claimants. The appropriator or his successor in interest has a right to the water so long as he uses it for some useful or beneficial purpose.

The waters appropriated may be turned into the channel of another stream and then reclaimed, provided the water appropriated by another is not diminished. The point of diversion may be changed also after the notice is posted, if no one is injured by such change.

Other laws and sections of the civil and political codes provide that joint users or owners of flumes, ditches, etc., are liable to each other for maintenance, repairs, and the distribution of the water in proportion to the share owned by each; that ditches shall be assessed for taxation as other real estate; that certain streams are navigable; that the stock of corporations selling, distributing, or delivering water to owners of the stock may be made appurtenant to certain lands; that persons buying land from a corporation selling water have a right to water from the corporation ditch; that flumes, ditches, and the like must not obstruct public highways; and that bridges, etc., must be maintained by the owners of the ditches.

Penalties and punishments have been provided for polluting water, obstructing canals, stealing water, disturbing headgates, cutting dams, banks, etc., and failing to provide fish screens for ditches, pipes, etc.

The irrigation district act, which was without doubt the most advanced step taken in securing for the irrigators the control of the systems under which they secure their supplies, was first considered in the legislature of 1871–72. Under this law three districts were organized by the legislature—the West Side in 1875–76, which included all irrigable lands west of the San Joaquin River from Tulare Lake to San Francisco Bay; the Modesto irrigation district; and the Los Nietos irrigation district, in Los Angeles County. Little

was done to carry out the provisions of the act, outside of the action taken by the legislature, doubtless because the country was sparsely settled and the need of irrigation not fully appreciated. When the Wright Act was passed in 1887 the development of the State's agriculture was assuming importance, and quarrels over water rights were becoming frequent and costly, and this measure seemed to afford a means of protection to the irrigators, as well as their individual control in the large canal systems. With the many amendments which have been enacted since the original law was passed, it would seem that its provisions would be of great assistance in bringing about a large development, but the failure of such a great percentage of the districts which were organized and the slowness in taking advantage of this law even to-day must be attributed to the difficulty in securing the aid of large financial interests in disposing of the bond issues. The only apparent relief seems to be to place the organization and management under State control and have either the county or State governments guarantee payment of both interest and principal. This would not mean any great change in this statute as it stands to-day, with the exception that the State engineer would approve of and supervise the plans, and the relation of the district directors would be more intimate with both the State and county governments.

Another matter greatly desired is that authority be given the State engineer to make a full investigation of all water privileges claimed, so that they may be tabulated in the order of their priority and adjudicate their claims according to the manner in which they have fulfilled the letter of the law regarding beneficial use. The latter term should also be given some fixed significance and the quantity necessary per acre for irrigation be placed between limits which investigations have shown sufficient for the best results. A bill proposed by the Water and Forest Association of California concerning the above points was introduced in the State legislature in 1903, and again in the session of 1909, but no action was taken in either case. Rights which have become vested could of course not be interfered with, but by placing the entire matter under the charge of the proper State official, with full powers of regulation, agricultural development would be given a great impetus.

IRRIGATION ENTERPRISES.

As stated before, the greater part of the development of irrigated lands in the State has been due to private enterprise, although the United States Reclamation Service has one project wholly and two partially in the State, and has made investigations with reference to the feasibility of other projects in different parts of the State.

Carey Act projects are unknown, owing to the fact that most of the agricultural lands are in private ownership. The extensive development is due largely to the enterprise and perseverance of the citizens and their confidence in the State's future.

RECLAMATION SERVICE PROJECTS.

ORLAND PROJECT.

This project is in the Sacramento Valley and lies wholly within the State. It includes at present about 14,000 acres in Glenn and Tehama Counties, principally in the former (fig. 1). The canals of the Lemon Home and Stony Creek Irrigation companies have been purchased, and, together with storage on Stony Creek, assure a continuous supply of water. The town of Orland is near the center of this project. There is promise that the present boundaries will be extended in the future, as the Government engineers have completed their surveys for the Iron Canyon reservoir on the Sacramento River above Red Bluff, which, if completed, will furnish water to large areas in Shasta, Butte, Tehama, and Glenn Counties. The cost of water rights on the Orland project has not been fixed. The land is all in private ownership and can be purchased for from $25 to $100 per acre.

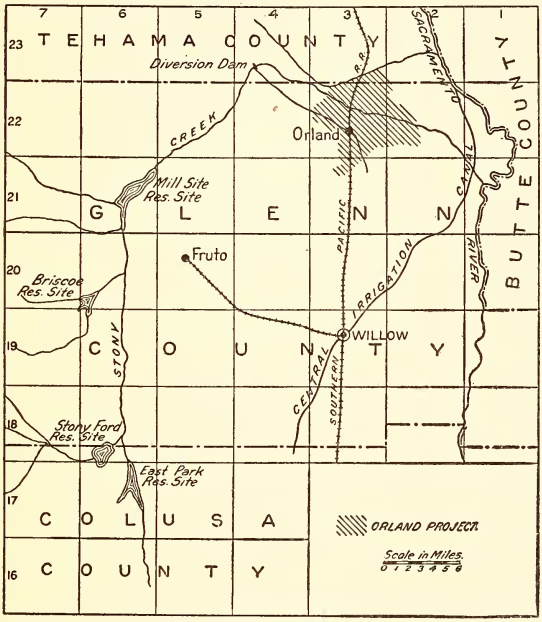

FIG. 1.—Orland project.

The East Park reservoir is at present under construction, while the other reservoir sites will be developed later. Water is being diverted through the purchased canal systems as formerly, and small portions of this project are being irrigated.

YUMA, OR LAGUNA, PROJECT.

This project is principally in Arizona, but will cover about 17,000 acres in the Colorado Desert in Imperial County, Cal. (fig. 2). The Laguna Dam is situated on the Colorado River, about 12 miles above

Yuma, and diversions will be made to both sides. The land on the California side is included in the Yuma Indian Reservation, and all but 4,000 acres, reserved for the Indians, is open to bona fide settlers. The land is largely public, and farm units will range from 20 acres upward, according to quality. The success which has attended irrigation in Imperial Valley, only a short distance to the southwest, gives great promise for development here. The dam was completed in April, 1909, and water is now being carried through the canals.

KLAMATH PROJECT.

This is an interstate unit, covering lands in Oregon and California (fig. 3). It is largely a drainage proposition in California, being the reclamation of swamp land surrounding Lower Klamath Lake and the lowering of the water level in Rhett (or Tule) Lake, in Siskiyou and Modoc Counties. No data are available as to the area to be reclaimed, as it is not known what effect the diversion of Lost River from its outlet in Tule Lake will have in lowering the waters of that lake.

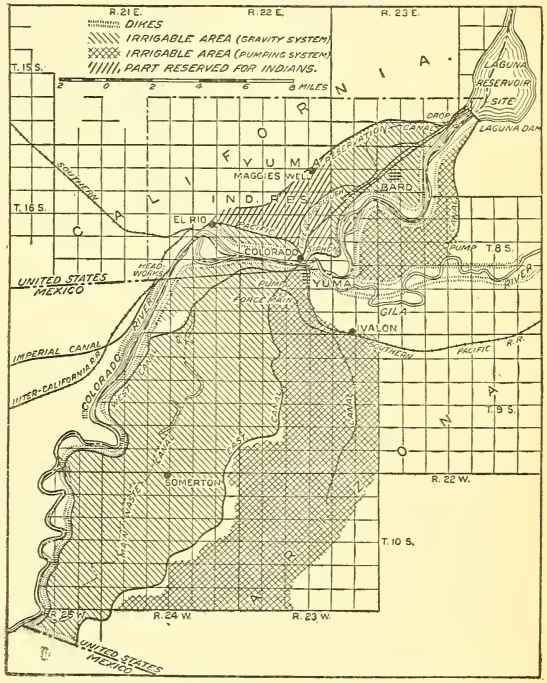

FIG. 2.—Yuma, or Laguna, project.

IRRIGATION DISTRICTS.

MODESTO DISTRICT.

This district lies entirely in Stanislaus County, between the Tuolumne and Stanislaus Rivers, and contains 81,143 acres of valley land (fig. 4). Water is diverted by means of the La Grange Dam, on the Tuolumne River, and delivered to the land through an elaborate system of canals. The outstanding bonds of this district amount to about $1,350,000, or an average of $16.64 per acre, to which must be added interest at 5 per cent per annum for the period the bonds run. The irrigated area is increasing rapidly, and during the season of 1909 more than 22,000 acres were served by these canals.

The district was organized in 1887, but with endless litigations to fight and many other troubles, 17 years elapsed before water was first run through the canals. With the present splendid organiza-

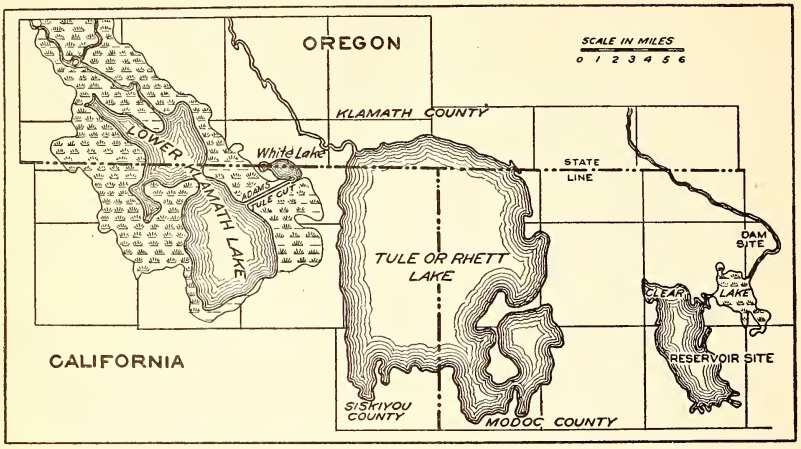

FIG. 3.—Klamath project.

tion rapid progress is being made in bringing all the area under water. Provision is being made to construct reservoirs to increase the late summer flow in the canals. Taxes for all purposes, including

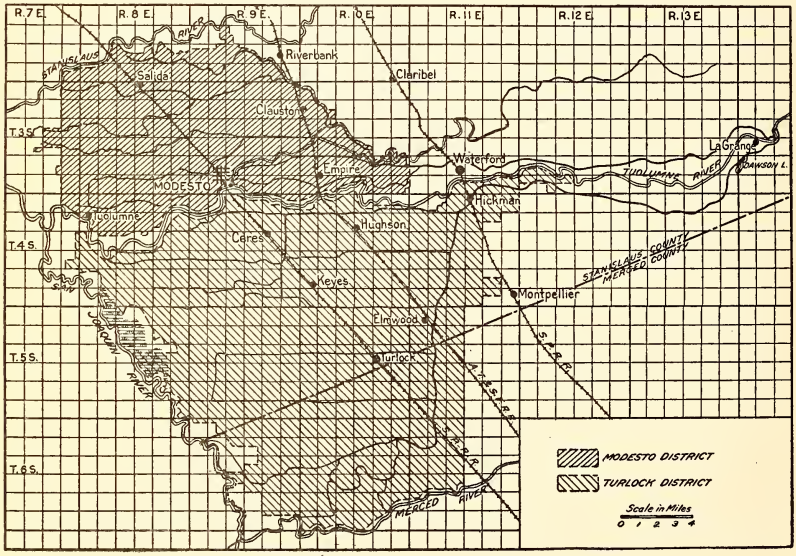

FIG. 4.—Modesto and Turlock irrigation districts.

maintenance and bond interest, amounted to $3 per $100 of the assessed valuation in 1907. All crops do well, and the water supply is ample.

TURLOCK DISTRICT.

This district lies just across the Tuolumne River from the Modesto district and extends southward to the Merced River (fig. 4). It includes nearly all the valley land between these two streams in Stanislaus and Merced Counties and embraces 176,210 acres. The La Grange Dam is the common source of supply for this and the Modesto districts. Its bonded indebtedness is about $1,302,000, or $7.39 per acre. This amount will be increased, as the district has on hand a number of authorized bonds which have not been sold. The organization was consummated about two weeks before the Modesto district and water was run in the canals for the first time in 1901. Nearly 52,000 acres were irrigated during 1909 and settlement is going on rapidly. The tax during 1907 for all purposes, including maintenance charges and interest on bonds, amounted to 3 per cent of the assessed valuation. The need of drainage has been realized in both Modesto and Turlock districts, and canals to relieve the high water table, with outlets into the San Joaquin River, are now in course of construction. With a thorough irrigation and drainage system in both districts the general condition of this section will be unequaled.

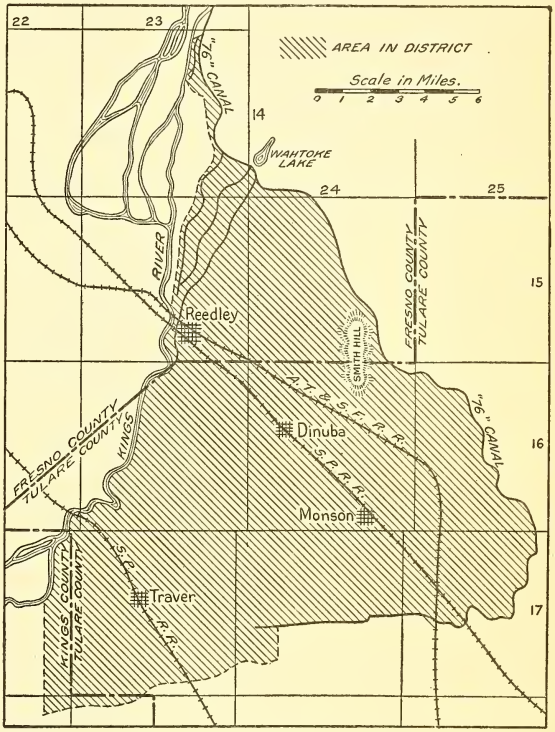

Fig. 5.—Alta irrigation district.

ALTA DISTRICT.

This district is located in Fresno, Tulare, and Kings Counties, and covers 130,000 acres, extending from the east and south bank of the Kings River to the Sierra foothills (fig. 5). It was organized in July, 1888, and the '76 Canal system was purchased to supply its

needs. This company did not have an early right on Kings River and the water is cut off usually in July. It receives water again during October and November by agreement with the earlier appropriators. About 80,000 acres is now under irrigation and the prosperous sections around Reedley and Dinuba have done much to place this organization on its feet. Outstanding bonds amount to $492,000. The district tax during 1908 amounted to 1.055 per cent for interest and 1.075 per cent for maintenance on the assessed valuation of the district. The scarcity of water during the summer months has been

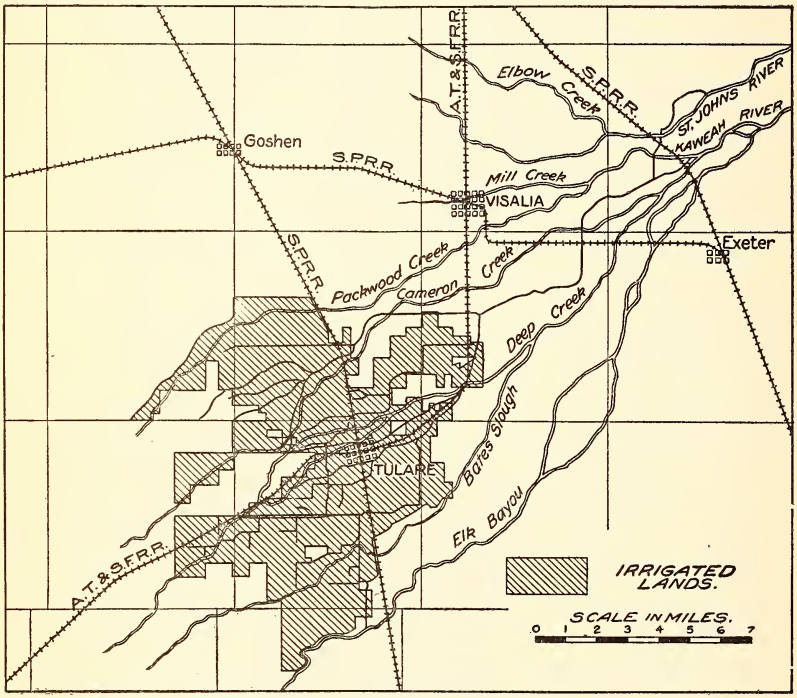

Fig. 6.—Tulare irrigation district.

overcome by the individual use of pumping plants. Water is close to the surface and a large supply can be obtained at shallow depths throughout the district.

TULARE DISTRICT.

This district was organized in June, 1889. It diverts water from the Kaweah and St. Johns Rivers in Tulare County, and includes 37,400 acres within its boundaries, of which about 12,000 acres were irrigated in 1909 (fig. 6). The city of Tulare is near the center of the district. Possibly more trouble was encountered here than in the

others described above, but the district is emerging gradually from its difficulties and getting on a firm basis. The water table is close to the surface over a large part of its territory and drainage is being considered seriously. Water rights here are similar to those in the Alta district and pumping is resorted to during the summer to augment the gravity supply. By agreement with the bondholders, the bonds, amounting to $500,000, were liquidated for $273,000 in 1903, the money being raised by a levy of 36 per cent of the assessed valuation. The maintenance charge in 1908 was $1.50 per acre actually irrigated. The entire district area is taxed on the assessed valuation for improvements to the system.

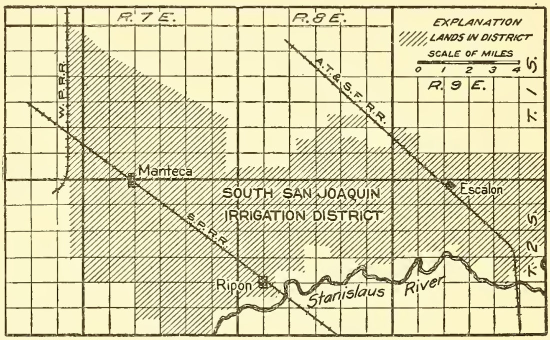

FIG. 7.—South San Joaquin irrigation district.

SOUTH SAN JOAQUIN AND OAKDALE DISTRICTS.

These districts were organized in 1909. The South San Joaquin district (fig. 7) includes about 71,000 acres on the north side of the Stanislaus River in the vicinity of Escalon, Ripon, and Manteca, and the Oakdale district (fig. 8) includes 65,000 acres lying on both sides of the river in the vicinity of Oakdale. The first has voted $1,875,000 worth of bonds to provide a good and complete irrigation and drainage system, and the latter $1,600,000 for an irrigation system. The two districts have purchased the water rights and canal system of the Stanislaus Water Company, and have nearly completed plans for the construction of a dam 80 feet high about 4 miles above Knights Ferry and for the construction of 8 miles of main canal having a carrying capacity of 1,700 cubic feet per second. The

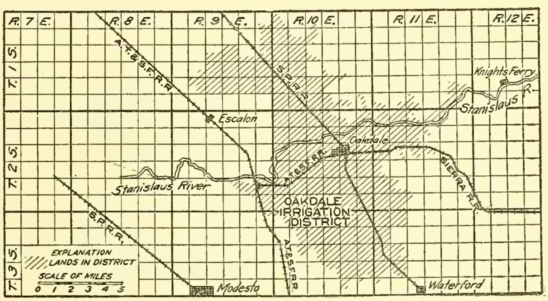

FIG. 8.—Oakdale irrigation district.

cost of the water right, dam, and headworks is to be borne jointly and the water divided equally.

The plans for the South San Joaquin district also include a reservoir about 3 miles northeast of Thalheim, with a capacity of about 75,000 acre-feet and costing $375,000.

Laterals will be built to each 40 acres. Where feasible the old ditches will be used, but no attempt will be made to patch up the old system. Two years at least will be required to construct the new canals and ditches, during which time the old system will be operated on a toll basis. The control of all canals and laterals will be in the hands of the district officers.

Great development should follow the installation of an adequate canal system, together with storage reservoirs and drainage where needed.

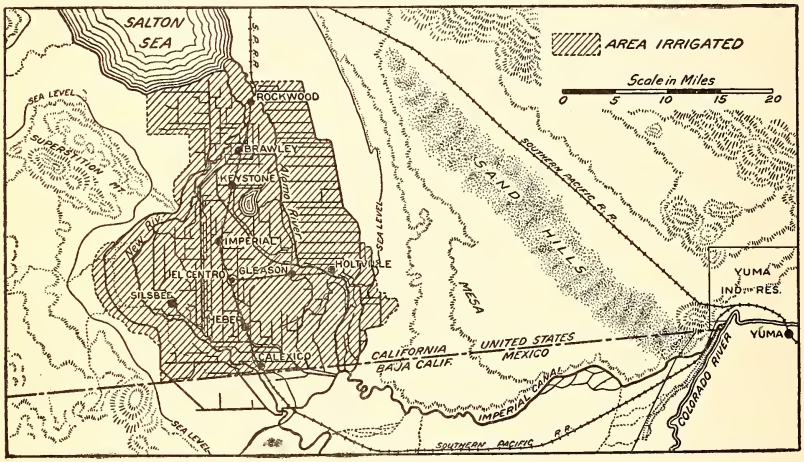

FIG. 9.—California Development Company.

The organization of a district to include about 10,000 acres near Paradise, on Little Butte Creek, in Butte County, is being considered seriously.

PRIVATE IRRIGATION SYSTEMS.

Following are given descriptions of a few of the most important of the very large number of private systems in various parts of the State:

CALIFORNIA DEVELOPMENT COMPANY.

This company diverts water from the west bank of the Colorado River close to the Mexican boundary line (fig. 9). Its main canal passes through a portion of the Mexican territory of Lower California, where approximately 100,000 acres is served. Reentering the State at about sea level it covers about 400,000 acres, mostly below

sea level, in the Imperial Valley, of which about 225,000 acres are irrigated at present. The company does not own any of the land, most of which has been taken up under the Desert Land Act. The company has organized the farmers on the main laterals into mutual companies, each of which controls its own system and elects and appoints its officials. The companies are known as Mutual Water Companies Nos. 1, 4, 5, 6, 7, 8, and 9, to which the California Development Company sells water at the rate of 50 cents per acre-foot and 4 acre-feet are considered sufficient for 1 acre. A deduction of 10 per cent is made from the quantity delivered at the head of each main lateral to cover seepage and evaporation loss. The mutual companies sell water rights to cover the cost of the distributing system, one share to each acre, at $15 to $25 per acre, each share held entitling the holder to a vote in the affairs of the mutual companies. The farmer pays 50 cents per acre-foot to the mutual company for the water he uses, as measured at his headgate, and also an annual charge for the maintenance of the system, amounting to about 20 cents per acre. This arrangement has worked out quite satisfactorily, and the valley is being developed rapidly, its unusual climate and rich soil making it attractive to home seekers.

The most remarkable feature is the high duty of water here, where it is necessary to irrigate throughout almost the entire year. A little over 2 acre-feet per acre has been found to be sufficient on the average during the past few years. The soil is mostly a finely divided silt mixed with clay. It is very deep and contains some alkali in spots. It holds moisture well and does not permit of rapid percolation, which fact, together with the method of selling water, may account for the high duty. The principal crops at present are alfalfa, barley, and melons.

SAN DIEGO FLUME COMPANY.

This system, which is typical of the coast region of southern California, irrigates at present about 7,000 acres to the north and east (fig. 10) of the city of San Diego from the San Diego River and storage reservoir. The main storage reservoir, known as the Cuyamaca, is on the headwaters of Boulder Creek, at an elevation of 4,600 feet, and has a capacity of about 12,250 acre-feet. The water is diverted from San Diego River at the mouth of Boulder Creek, 12 miles below the reservoir, and carried to the irrigated orchards in the vicinity of San Diego by means of a 4 by 6 foot wooden flume 35 miles long. There are five tunnels and numerous high trestles along the route. The San Diego River is dry for four to five months in the year, at which time the stored water is used. The La Mesa reservoir, near the coast, which stores about 1,500 acre-feet, is a part

of the system also. Three other reservoirs are proposed for this system—Lake Helena and Dry Valley in the drainage basin of the San Diego River, and the Pine Valley in the drainage of Cottonwood Creek.

The flume line ends in a small reservoir near the city limits of San Diego, from which point water is conducted through pipes to the various orchards. It is also tapped along its course, but when this is done it is necessary that a constant flow be taken at a cost of $60 per miner's inch per year.[1] Along the pipe line water is measured by means of meters and the same rate is charged as on the flume line.

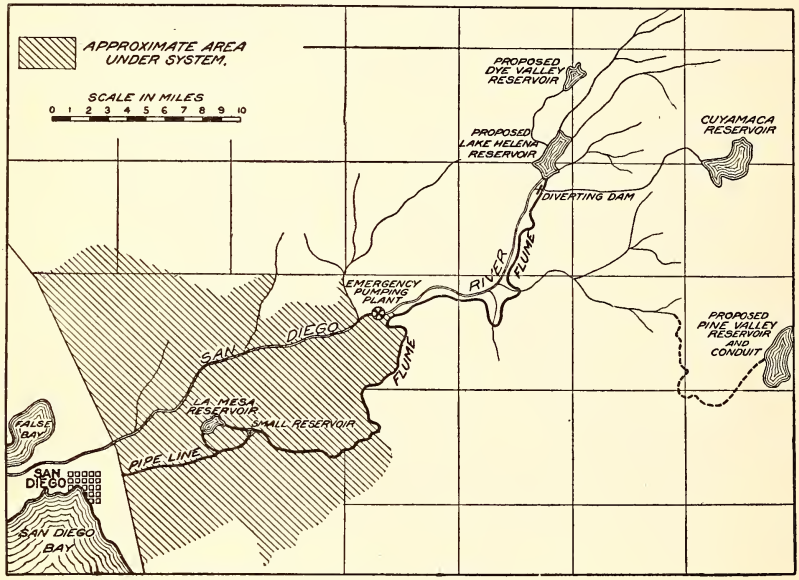

FIG. 10.—San Diego Flume Company.

Water rights are sold at the rate of $800 per miner's inch and are appurtenant to the land. A 1-inch flow is considered sufficient to irrigate 8 to 10 acres. A pumping plant is established also, as shown in figure 10, to be used in case of emergency. As this water must be raised 300 feet, it is sold by the 1,000 gallons at an increased rate.

The torrential flow of the San Diego during the winter makes storage, in accordance with the plans of the company, possible, and when developed a larger area will be available for irrigation. The orchards under this system, mostly lemons and oranges, are very profitable even with the high cost of water.

[1] Measured under 4-inch pressure above the center of the orifice.

RIVERSIDE WATER COMPANY AND GAGE CANAL COMPANY.

These two systems serve the valuable lands between the south bank of the Santa Ana River and the hills, from the section east of Colton through the Riverside district in San Bernardino and Riverside Counties, but are in no way connected with each other. The former company covers the lower lands, while the latter furnishes water to those nearer the foothills, including Arlington Heights.

The Riverside Water Company was organized by the irrigators under it, with 24,000 shares of stock, two shares being held for each acre, 12,000 acres being the limit of the service. In 1908 there were irrigated 9,050 acres, nearly two-thirds of which was in orange orchards and the greater part of the balance in alfalfa. The stockholder operate and control the system. Water is diverted from Warm Creek and the Santa Ana River at its junction with this creek, about one-half mile east of Colton (fig. 11). The supply is increased also by artesian wells and pumped water. The river is crossed by means of a wooden flume.

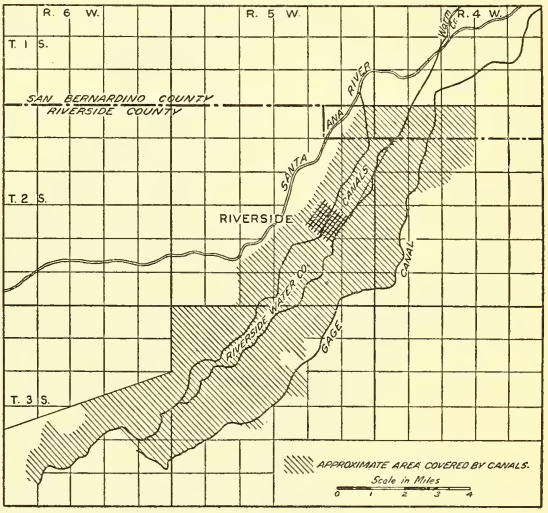

FIG. 11.—Riverside Water Company and Gage Canal Company.

The main canal is lined with concrete cement and the distributory system is largely pipe lines, conveying water to the highest point on each 10 acres. Every effort is made to prevent seepage and evaporation losses. The value of the entire system, which includes the municipal supply of Riverside, is estimated at $2,500,000, the irrigation portion alone being valued at nearly $1,000,000. The price of water varies with the season, but averages 17 cents per miner's inch for 24 hours, the highest price being 25 cents per inch for 24 hours from July 15 to October 30, and the lowest 10 cents per inch for 24 hours, from November 1 to February 28. A charge of $12 per acre per year, with unrestricted use, is made also. The duty of water is about the same as under the San Diego Flume Company.

The Gage Canal Company diverts water from the Santa Ana River about 3½ miles above the diversion point of the Riverside Water Company (fig. 11). Its flow is largely augmented during the summer by numerous artesian wells and pumping plants. About 9,500 acres were irrigated in 1907, mostly in orange orchards, but the system will cover about 2,000 acres more when fully developed. This is probably the most highly developed system in the United States, no expense being spared to prevent seepage loss or to give a satisfactory service. As in the Riverside Water Company, water is delivered at the highest point on each 10 acres at a rate based on the equivalent of two-tenths miner's inch continuous flow for each acre. Water may be allowed to accumulate and the irrigators usually take

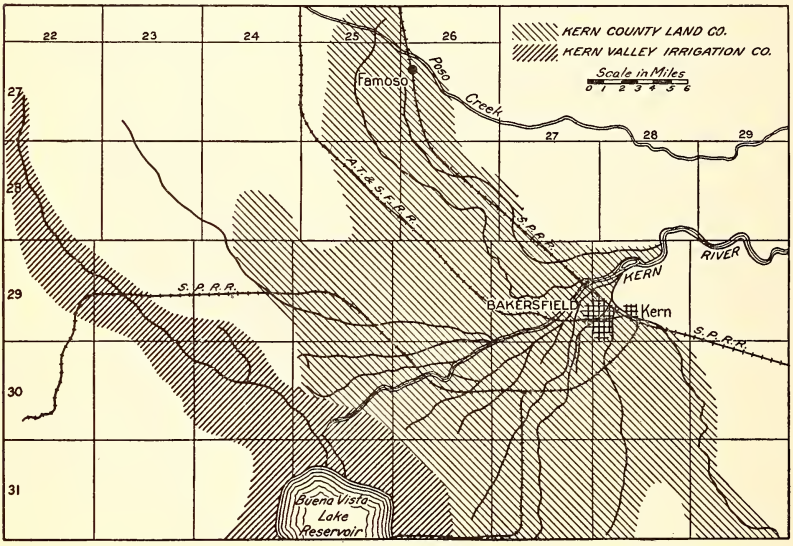

FIG. 12.—Kern County Land Company and Kern Valley Irrigation Company.

their supply every 30 to 45 days. The distribution is by rotation and the company must be notified a certain number of days in advance in order to deliver an irrigator's supply. Water rights are sold for $1,000 per miner's inch, or $200 per acre. The yearly cost for maintenance and improvements is about $3 to $5 per acre. The greater part of the area under this system is in a very high state of cultivation and some of these improved lands are valued as high as $3,000 per acre. As in the neighboring system, pipes are used in delivering to the individual irrigators. Measurements of water are made as accurately as possible and no difficulties are encountered from that source.

KERN COUNTY LAND COMPANY.

This company diverts water from both sides of the Kern River by numerous canals, which cover about 250,000 acres in the vicinity of Bakersfield (fig. 12). The larger part of the water is used to irrigate their own lands. Water is sold by quantity at the rate of 75 cents per cubic foot per second, flowing for 24 hours, which is equivalent to 37½ cents per acre-foot. About 116,500 acres are irrigated at present, of which 70,000 acres are in alfalfa, 34,000 in grain, 12,000 in native pasture, and the balance in orchards and vineyards. The area in native pasture varies considerably from year to year. Large acreages of pasture are checked, single checks containing as high as 150 to 200 acres, and when the water supply is ample the irrigation of these extends over an extensive area. Development in this section has been somewhat slow as compared to neighboring counties to the north, although climatic and soil conditions are similar and the water supply is ample.

KERN VALLEY IRRIGATION COMPANY.

This company irrigates riparian lands from Buena Vista Lake northward along the old channel that connects that lake with Tulare Lake (fig. 12). No water is sold and about 63,000 acres in grain, alfalfa, and native pasture belonging to Miller & Lux are irrigated. A storage reservoir was formed by the construction of a levee along the east bank of Buena Vista Lake to prevent its overflow from reaching Kern Lake. The question of riparian ownership on this stream gave rise to the famous case of Lux *v.* Haggin, in which the claims of riparian owners were first legally fought out. Although these litigations were carried on for a number of years, no definite decision was reached and the matter was finally settled by compromise between the litigants, the flow of the Kern River now being divided between the Kern County Land Company and Miller & Lux.

FRESNO AND CONSOLIDATED CANALS COMPANIES.

These two systems, although kept separate, are operated by the same people and cover practically all the irrigated lands in Fresno County, amounting to about 360,000 acres (fig. 13). The points of diversion for the various canals are all along the west bank of Kings River, close to where it enters the valley. The Fresno Canal system is one of the oldest of the large irrigation concerns in the valley, having been constructed in the early seventies, and was the beginning of the agricultural development in this county. The Gould and Enterprise Canals are included within this system also.

The Consolidated includes the Fowler Switch and the Centerville and Kingsburg Canals, as well as a majority of the stock of the Emigrant Canal. The latter is on the lower Kings River, and diverts water from the river 6 miles west of Kingsburg to irrigate lands on the Llaguna de Tache rancho, which belongs largely to this company.

Water rights are sold at the rate of 1 cubic foot per second continuous flow for each 160 acres, the price varying from $1,600 for first-class rights under the Fresno system to about $800 for second-class rights under that system and the rights of the Consolidated. These rights do not represent any interest in the affairs of either com-

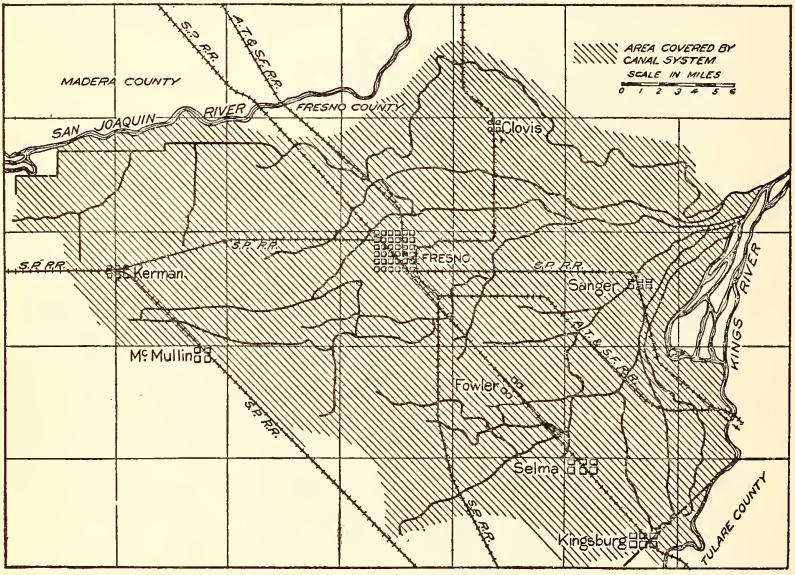

Fig. 13.—Fresno and Consolidated Canal companies.

pany, being merely a right to the use of water flowing in the canals, and when located on the lands they are appurtenant thereto and can not be removed.

The Fresno system has an early priority on the Kings River, amounting to 1,000 cubic feet per second, which gives 1,000 first-class rights, but, as quite an area of the earlier irrigated section does not need water on account of the high water table, second-class rights amounting also to 1,000 cubic feet per second have been sold. By agreement these rights are entitled to the water not used under the first-class rights, but do not receive any if the first-class rights demand the entire flow of the canal. Little trouble has been experienced thus far by the holders of these second-class rights. Water can be obtained usually under this system up to September 1, and

in years of plentiful supply up to October 1. The Consolidated has later priorities on the river, and its flow is cut off from the middle of June to August 1, so that its rights do not have the value of Fresno rights. An annual charge is made for the maintenance of the main canals, amounting to 62½ cents per acre under the Fresno and 75 cents per acre under the Consolidated. The lateral ditches are owned and controlled by the irrigators. This district contains over 100,000 acres in vineyards, about 30,000 acres in orchard, and a large acreage in alfalfa. Considering its area, it is the most highly developed dis-

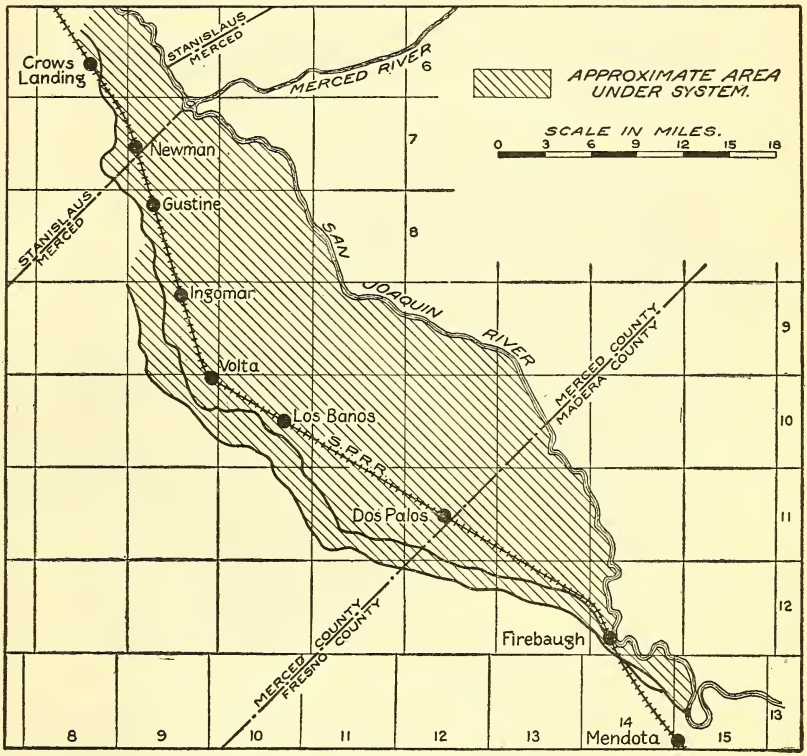

FIG. 14.—San Joaquin and Kings River Canal and Irrigation Company.

trict in the State. The land is owned chiefly in small holdings of 20 to 80 acres. The principal products are raisins, sweet wines, brandies, dried and canned fruits, and butter.

No measurements are made to users, each irrigator taking what he needs in accordance with rights held by him.

THE SAN JOAQUIN AND KINGS RIVER CANAL AND IRRIGATION COMPANY.

This system diverts water from the west bank of the San Joaquin River about 1½ miles north of the town of Mendota in Fresno County (fig. 14). It is the oldest large canal in the valley. The area tribu-

tary to it extends for 70 miles along the west bank of the river in Fresno, Merced, and Stanislaus Counties. This company belongs to Miller & Lux, who have riparian rights on the river, and their own lands are very largely included. About 340,000 acres of land are irrigable from this system, although at present only one-third is served, of which 40,000 acres are in private ownership, and purchases water from the company. No water rights are sold; the water is measured to the users and charged for on the basis of a flow of 1 cubic foot per second for 24 hours. An annual per acre charge was made until recently. This was higher than the rates fixed by the

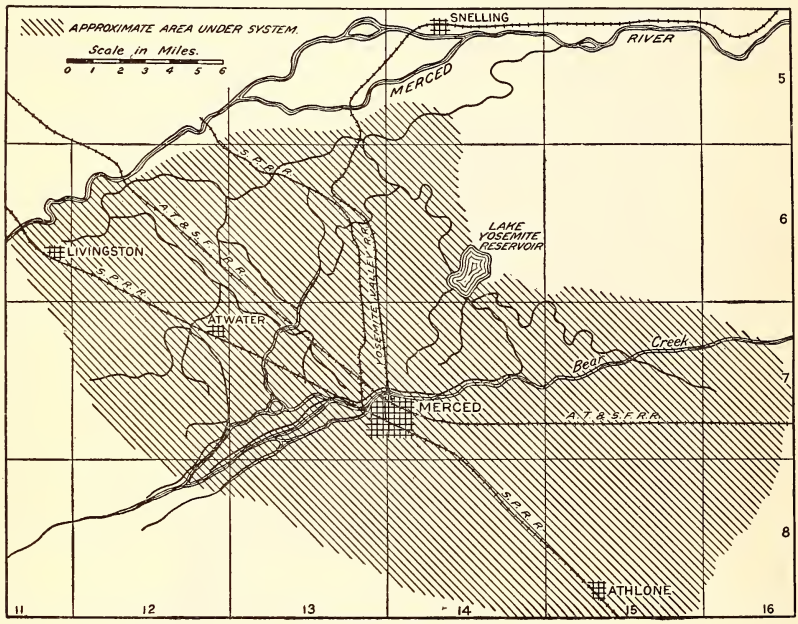

FIG. 15.—Crocker-Huffman Land and Water Company.

supervisors in the three counties through which the canal passes, and resulted in suits between the company and the county officials, as the returns from the fixed rates did not pay interest on the money invested. Charges for water were fixed by the company during the past two years, as follows:

In Stanislaus County, $2.35 for 1 cubic foot per second, flowing for 24 hours, or $1.17½ per acre-foot.

In Merced County, $1.90 for 1 cubic foot per second, flowing for 24 hours, or 95 cents per acre-foot.

In Fresno County, $1.25 for 1 cubic foot per second, flowing for 24 hours, or 62½ cents per acre-foot.

It has been found that the duty of water is much higher under the new system of charging than formerly, the irrigators being far more careful not to waste water.

The lands under this system include a large area of swamp and overflow land along the river. This is flooded during the high water by means of large checks, and produces pasturage during the summer and fall months for large herds of cattle belonging to the company.

The improved lands under this system are in alfalfa principally, with some orchards and vineyards in the Dos Palos colony.

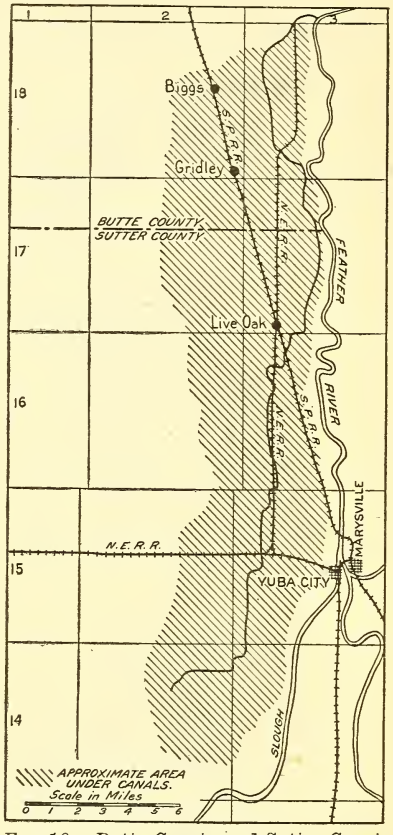

FIG. 16.—Butte County and Sutter County Canal companies.

CROCKER-HUFFMAN LAND AND WATER COMPANY.

The Merced River furnishes the supply for the 220,000 acres irrigable from its canals. These lands extend from the foothills near where the river enters the valley to the country surrounding the city of Merced and between that city and Livingston (fig. 15). The point of diversion is in the foothills about 4 miles east of Snelling, from which point the water is carried to a reservoir known as Lake Yosemite, 6 miles north of Merced. Several laterals take out water between these points to irrigate the Livingston and Atwater regions. Only a small proportion of the land is irrigated at present, but settlement is going on rapidly, especially near Atwater.

Water rights are sold at $10 per acre and are based on a continuous flow of 1 cubic foot per second for each 160 acres. The water rights represent no interest in the control of the company. An annual charge is made of $1 per acre for maintenance of the main canal system. Small laterals are built and cared for by the irrigators. Alfalfa is the principal crop irrigated.

THE BUTTE COUNTY AND THE SUTTER COUNTY CANALS.

These two canals are controlled by the same people, using the same main canal, but are separately incorporated. The Butte County Canal serves the area in Butte County, and the Sutter County Canal serves that in Sutter County (fig. 16). This system covers about 80,000 acres—30,000 in Butte and 50,000 in Sutter County—composed

of the lands between the Feather River, the Marysville Buttes, and the swamp lands along the Sacramento River south to where the slough which leaves the Feather River near Marysville joins the Sutter Basin. The point of diversion is on the west bank of the river, 6 miles northeast of Biggs. The canal follows the highland parallel and near to the Feather River and irrigates the lands on both sides. The charge for water rights is $10 per acre, based on a continuous flow of 1 cubic foot per second for each 160 acres. The water rights, however, do not confer any interest in the canal company. A maintenance charge of $1 per acre in Butte and $2 in Sutter County is made for keeping up the main canal, while laterals are controlled by the irrigators. The company has considerable areas under the canal which have been divided into colonies of 10 and 20 acre tracts. The lateral systems to these colonies are built by the company so as to deliver water to the highest point on each tract. These lateral ditches are incorporated, and each purchaser in a colony tract becomes a shareholder in the lateral company in accordance with the acreage owned by him. The canal company then deals with the lateral company direct, each irrigator being liable for his share in maintaining the lateral ditch, besides the charges made by the parent company.

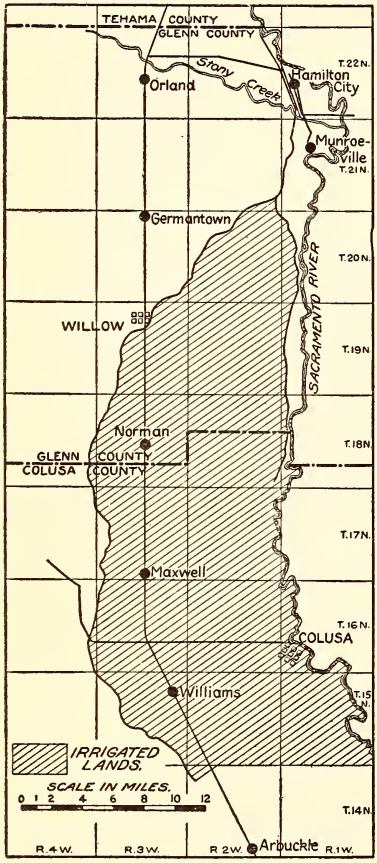

FIG. 17.—Sacramento Valley Irrigation Company.

A rock-fill dam has been constructed to divert the water into the canal during the period of low water in the middle of the irrigating season. About 10,000 acres are under irrigation at present, the principal crop being alfalfa, although orchards and vineyards are being planted also.

SACRAMENTO VALLEY IRRIGATION COMPANY.

This is a recent enterprise backed by large eastern financial interests, which have secured the rights of the Central Irrigation District by the purchase of all outstanding district bonds for 35 per cent of

their par value. They have secured control also of 100,000 acres in the above district and are carrying on extensive work in preparing for the irrigation and drainage of the 225,000 acres which will be included in their system (fig. 17). The people back of this enterprise have had extensive experience in developing irrigated areas under the Carey Act in several of the Western States, and their method of procedure will be unique in the history of large irrigation enterprises in this State.

The Central Irrigation Canal, which diverts water from the west bank of the Sacramento River about 2 miles south of the county line between Tehama and Glenn Counties, will be their main canal. This canal runs first in a southeasterly direction to Willow and from there in a general southerly direction almost to the town of Arbuckle, in Colusa County. All lands between this main canal and the Sacramento River are included in the project. A careful topographical survey, with contour intervals of 6 inches, is being made of all the lands. Laterals will be constructed to the highest point on each 40 acres and purchasers of land will be required to level their holdings in accordance with the contour surveys. Water rights will be appurtenant to the land and will convey also an interest in the canal company so that when more than 50 per cent of the lands are sold the management of the system will be in the hands of the irrigators.

In the division and distribution of water the most advanced ideas will be incorporated, and a higher duty will be maintained than on any system in the State where water is sold at a flat rate per acre. The installation of a drainage system at the same time as the irrigating canals will insure the lands against damage from a high water table which has ruined many fertile acres of irrigated lands in the State. The cost of water per acre has not been fixed, as the construction work is not sufficiently advanced to be able to decide the per-acre cost.

AREA OF LANDS UNDER CANALS.

The following table shows the acreage of irrigable lands under existing canals from the different streams in the State:

Area of irrigable lands in California under existing systems.

Streams.	Counties.	Acres.
Southern California:		
Colorado River	Imperial, Riverside	[1] 450,000
Sweetwater, San Diego, and San Luis Rey Rivers.	San Diego	[2] 400,000
Santa Ana River	San Bernardino, Riverside, and Orange	
Los Angeles and San Gabriel Rivers	Los Angeles	
Santa Clara and Ventura Rivers	Ventura	
Santa Ynez and Santa Maria Rivers	Santa Barbara and San Luis Obispo	
Total		850,000

[1] Includes wells, etc., in Coachella Valley.

[2] Includes pumping plants, artesian wells, etc.

Area of irrigable lands in California under existing systems—Continued.

Streams.	Counties.	Acres.
Coast Country:		
Salinas River	Monterey	40,000
Pajaro River	San Benito, Santa Clara, Santa Cruz	20,000
Lower Santa Clara Valley	Santa Clara	20,000
San Francisco Bay region	Santa Clara, Alameda, Contra Costa	5,000
Total		[1] 85,000
San Joaquin Valley:		
Kern River	Kern	250,000
Tule River	Tulare	44,000
Kaweah River	Tulare	100,000
Kings River	Fresno, Tulare, Kings	600,000
San Joaquin River	Fresno, Merced, Madera, Stanislaus, San Joaquin.	[2] 500,000
Fresno River	Madera	20,000
Merced River	Merced	220,000
Tuolumne River	Merced, Stanislaus	270,000
Stanislaus River	San Joaquin, Stanislaus	100,000
Mokelumne River	Amador, San Joaquin	32,000
Cosumnes River	Sacramento, Amador	5,000
Miscellaneous streams and pumping plants		9,000
Total		2,150,000
Sacramento Valley:		
American River	Sacramento, Placer, El Dorado	10,000
Bear River-Yuba River	Placer	30,000
Feather River	Butte, Sutter	100,000
Butte-Chico Creeks	Butte	2,000
Putah Creek	Yolo, Solano	5,000
Cache Creek	Yolo	30,000
Stony Creek	Tehama, Glenn	15,000
Sacramento River	Tehama, Glenn, Colusa, Sacramento	[3] 325,000
Upper Sacramento Valley:		
Clear Creek, Cottonwood Creek, Mill Creek, and others.	Tehama, Shasta	40,000
Pitt River	Medoc, Siskiyou, Shasta	65,000
Miscellaneous streams		8,000
Total		630,000
Miscellaneous streams of State:		
Klamath River	Siskiyou	35,000
Susan River	Lassen	40,000
Owens River	Inyo	43,500
Mohave River	San Bernardino	1,000
Other streams		41,500
Total		161,000
Grand total		3,876,000

[1] Includes pumping plants.
[2] Includes reclaimed swamp lands near Stockton.
[3] Includes swamp lands below Sacramento.

Of this grand total about 2,500,000 acres are being actually irrigated at present. This includes a considerable area of native meadow and wild grass lands and also over 200,000 acres in the reclaimed swamp lands at the mouths of Sacramento and San Joaquin Rivers. The settlement and development of the balance of this large area are progressing rapidly in some sections and slowly in others. With better laws to control and regulate diversions from the streams of the State, and therefore a guarantee for the safe investment of capital in irrigation enterprises without expensive litigations which have been incident heretofore with appropriations from the natural watercourses, the State can expect a much larger population throughout the agricultural districts and a great addition to its wealth.

COST OF PREPARING LAND FOR IRRIGATION.

The valley lands west of the Sierras as a rule contain no brush or trees which require clearing, being covered for the most part with annual grasses and weeds which do not form a sod. There is, therefore, little expense in breaking the land and putting it in shape for crops. The leveling of a tract for irrigation is of the greatest importance, however, and the care with which this is done has a large bearing on future success. As a rule this is done with buck scrapers and finished off with home-made implements, such as a leveler, float, etc. The cost varies from $5 to $35 per acre, according to the crops to be planted and the condition of the surface. East of the Sierras sagebrush, greasewood, and similar growths are found, and the cost of their removal is $3 to $5 per acre, according to the methods used. The most common method is to use a heavy railroad rail with a team attached to each end. This is dragged first in one direction and then in the opposite direction, the best time being when the ground is wet or frozen. After the dragging any brush remaining is grubbed out. Machines of very heavy construction made in V-form, shod with heavy steel knives on the outside and pulled from the apex of the V by traction engines, have been used also.

In the foothills brush and trees are encountered and the cost of clearing averages about $35 an acre. The brush and small trees are removed when the ground is wet by a cable and hook with team attached, while trees, principally pine and oak, must be grubbed out. The cost of such work is paid for usually by the firewood obtained. Cutting the wood in suitable lengths and splitting it can be contracted for usually at $1.50 to $2.50 per cord, and the split wood is worth about $4 to $6 per cord on the ground. The preparation of alfalfa land entails the greatest expense usually, as it is leveled and checked in such manner as to require the least amount of labor in irrigating. Two methods of irrigating it are common to the State—border and basin checks. The former is coming more into favor each year, as less work is required in preparing the fields and there is less danger of drowning out the crop if the land is properly leveled. Both methods are fully described in bulletins of this department.[1]

Orchard and vineyard lands are leveled off evenly throughout with a uniform slope in the direction of the natural fall of the country. Various methods of orchard irrigation are practiced, which are fully described also in a Farmers' Bulletin.[2]

Another important irrigated crop which is now receiving considerable attention, especially in the Sacramento and San Joaquin Valleys, is sugar beets. Methods used in successfully handling this crop are described in a Farmers' Bulletin of this department.[3]

[1] U. S. Dept. Agr., Farmers' Buls. 263 and 373.
[2] U. S. Dept. Agr., Farmers' Bul. 404.
[3] U. S. Dept. Agr., Farmers' Bul. 392.

In preparing a bulletin on a subject of such wide scope as irrigation in California, it is not possible to go into details without overburdening the publication. The Office of Experiment Stations is preparing a series of bulletins, however, in cooperation with the State, on irrigation in various sections. Some of these have been published, while others will appear later. These go more into detail than is possible in this general survey of the subject. The necessity of applying water artificially to the soil in the production of crops throughout almost all of the State and the vast increase in values of lands incident thereto make this subject of prime importance in the State's future development and prosperity. It is to be hoped, therefore, that its water resources, which are without doubt its most valuable asset, may be so administered eventually that its agricultural, mining, power, and navigation development, as well as its domestic supply, may develop side by side in harmony.

[Bull. 237]

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